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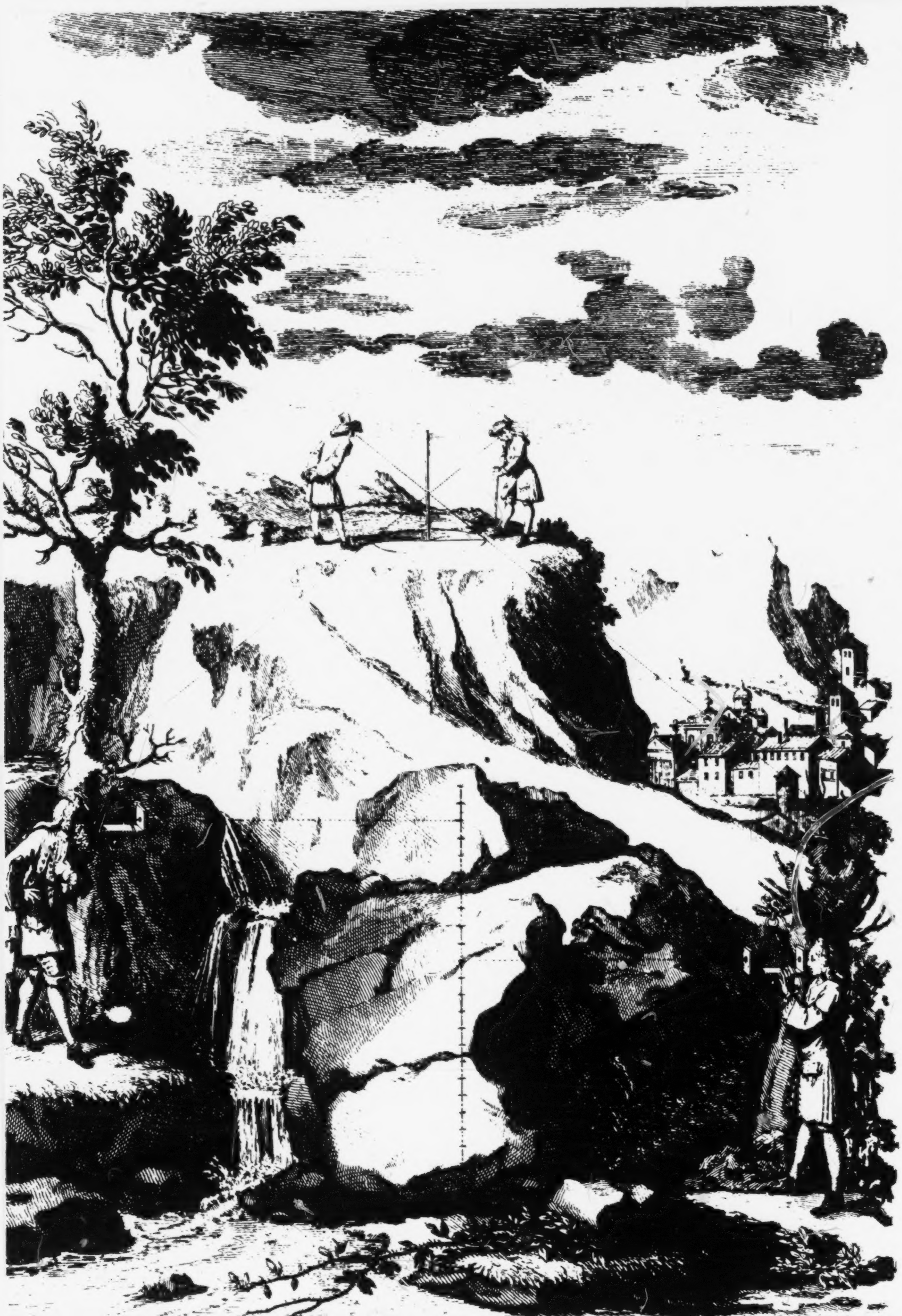
ABSTRACT

One hundred and fifty papers deal with the current range of concerns in the emergent field of environmental design research and emphasize the relating of research to practice. The papers focus on (1) original research in the social and behavioral sciences with direct relevance to environmental design, planning, and management; and (2) new methods and approaches (including computer-based techniques) for dealing with complex environmental problems. The papers are grouped under (1) man-environment relations, (2) environmental quality -- specification and evaluation, (3) design -- the generation and exploration of solutions, (4) design communications -- methods and media, and (5) design research and education. (Author/MLF)

ENVIRONMENTAL DESIGN: RESEARCH AND PRACTICE ONE

proceedings of the edra 3/ar 8 conference, university of california at los angeles, january 1972, edited by william j. mitchell



ENVIRONMENTAL DESIGN: RESEARCH AND PRACTICE ONE

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PREFACE

INTRODUCTION (By William J. Mitchell, Chairman Conference Planning Committee)

This is a smorgasbook, a representative collection of one hundred and fifty papers dealing with the current range of concerns in the emergent field of environmental design research; from this diverse array you can select the particular topics which interest you.

It is a record of presentations at the Environmental Design Research Conference, held at the School of Architecture and Urban Planning, University of California, Los Angeles, on January 24-27, 1972. This international conference was a joint program of the Third Annual Environmental Design Research Association Conference (EDRA-3) and the Eighth Annual AIA-Architect-Researchers' Conference (AR-8).

As in previous years, papers prepared for the EDRA3 Conference focused on original research in the social and behavioral sciences with direct relevance to environmental design, planning, and management, together with new methods and approaches (including computer-based techniques) for dealing with complex environmental problems. The organizers of the AR8 Conference also sought contributions in these fields of concern, but specifically emphasized the question of relating research to practice. The joint program brought together researchers, practitioners, and those working on the interface.

The call for papers was widely distributed in the U.S.A., Canada, the U.K., and Australia. Over four-hundred architects, planners, social and behavioral scientists, engineers, industrial designers, and computer scientists responded with submissions. A staff of sixty reviewers read them, and selected those reproduced here for presentation.

Each author was responsible for the production of camera-ready copy for his paper, which was then photographed, and printed by an offset process. In this way, each contributor communicates directly with the reader; there is no editorial process intervening to rearrange, distort, or subvert his ideas. Furthermore, it is an extremely quick and cheap method of production.

The grouping and ordering of papers into sessions and sections was done according to a conceptual scheme which makes sense to me. No doubt it is somewhat idiosyncratic, and it may not make much sense to others. This is probably unavoidable in such a rapidly evolving field. Any attempt to categorize papers irresistably recalls Borges' now-famous "Imaginary Chinese encyclopedia," in which "animals are divided into: (a) belonging to the Emperor, (b) embalmed, (c) tame, (d) sucking pigs, (e) sirens, (f) fabulous, (g) stray dogs, (h) included in the present classification, (i) frenzied, (j) innumerable, (k) drawn with a very fine camelhair brush, (l) et cetera, (m) having just broken the water pitcher, (n) that from a long way off look like flies." If my taxonomy is of a little use to you as that of stray dogs and sucking pigs, you can at least find the papers that you want by means of the author index.

The EDRA Conferences (By Henry Sanoff and Sidney Cohn, Co-Chairmen EDRA Steering Committee

About a decade ago, when the design professions were faced with increasingly complex environmental problems which defied satisfactory solutions, a few designers came to realize that both their traditional problem solving methodology and their knowledge of the man-environment system was highly inadequate. They realized that their training as designers left them unequipped to understand the problem or to develop effective solutions. Seeking to improve this state they sought the assistance of scientists who were concerned with the study of man. They found for the most part the work of the sciences was unrelated to environmental design research and problem solving. Fortunately, however, they found a few scientists interested in studying this problem area.

Through the initiation of the Design Methods Group Newsletter, contacts were established which then led to a first major confrontation of 175 designers and scientists, which occured in 1967 at MIT, for the Design Methods Group meetings. This group held a primary interest in models of the design process, design assistance techniques and computer-aided methods. In addition to producing a major publication of the proceedings (Emerging Methods in Design and Planning, edited by Gary Moore), the leaders of this movement recognized a substantial lack of participation from the social and behavioral sciences and proceeded to expand the scope of interest to issues of environmental design. The premise for the realignment was based on the need to provide an input of substantive knowledge of the environment to the organized methodological interests already developed.

EDRA was formed, then, as a group committed to the notion of the environment as an integral part of the human system and as a facillator of multi-disciplinary collaboration between design and the sciences. Subsequent publications such as Man-Environment Systems, Journal of Environment and Behavior, and Design and Environment, have served to reinforce the need for large group contacts as well as informal discussion groups, on a continuing basis.

The First EDRA meeting in 1968 at North Carolina brought together 200 designers, planners and scientists from all parts of the world to discuss their work, which included externalization of systematic problem solving techniques; computer assistance methods; and the development of social and behavioral knowledge about the man-environment millieu. Today, these basic areas of development are giving rise to new approaches generated by combinations of the basic types of investigations.

The major focus of the annual meetings of EDRA has evolved around the development of models and methods leading towards the framework of a coherent and definable structure for environmental design. The proceedings of both previous meetings are published in two volumes entitled EDRA-1 (Sanoff and Cohn, editors) and EDRA-2 (Eastman and Archea, editors).

Our long-range goal is the general recognition and acceptance of the field of Environmental Design, which is not confined to narrow disciplinary approaches. More immediately, we seek to emphasize the significance of research in design and encourage the emerging new hybrid, environmental design researchers. We also feel the need to encourage scientists concerned with the environment to direct their research interests to a responsive group. Finally, we hope to encourage environmental designers to be involved in research and incorporate those findings in their design efforts. While the history of EDRA is quite brief, its role in the context of environmental problems is crucial. The rapid growth of scholarly writings in this area is a sufficient indicator of its importance and future impact.

The AIA Architect Researchers Conference (By Don Conway, AIA's Director of Research Programs)

In 1964 the American Institute of Architecture established the Annual AIA-Architect-Researchers' Conference with the support of a small grant from the AIA Supplementary Dues Fund. The first Conference was held in Washington, D.C. and was attended by about forty people.

Since that time Conferences have been held at the University of Michigan; Washington University, St. Louis; University of Tennessee; in Wisconsin, in Houston, and at the University of Cincinnati. Attendance has grown to about 350 people.

In 1971, for the first time, the Conference was held jointly with the Environmental Design Research Association (EDRA), an informal organization of man/environment researchers.

The purpose of the Conference is to provide a forum through which architects (and others) who are involved in and/or particularly interested in research for architecture can get together to discuss matters of mutual concern and present papers for exchange of information and evaluation.

Annual AIA-Architect-Researchers' Conferences result from the desire of individuals actively engaged in research to review current research efforts and to discuss the ramifications for the profession. As a consequence, the topics presented and discussed at the AR Conferences often precede general awareness of new design and building techniques, products and materials developments, or evaluations of architectural methods and design influences.

This year's changes in conference format and relation to the EDRA Conference, are part of a continuing effort to get researchers and practitioners talking to each other. This is the way it's got to be, if research is really going to produce better environment.

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MAN-ENVIRONMENT RELATIONS

1: COGNITIVE MAPPING

THE CONCEPT OF HOME RANGE: NEW DATA FOR THE STUDY OF TERRITORIAL BEHAVIOR

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Abstract

The concept of home range is explored and some of its properties and determinants discovered from 'turf maps' of children. An experiment in eliciting objective measures of home range reveals a method which holds some promise for cross-cultural as well as developmental study of children's home range.

Introduction

Although human geography is a social science whose central concern is man's spatial and environmental behavior, the focus of most traditional research has been upon areal or population aggregates rather than upon individuals. Only recently has the 'behavioral revolution' shifted our sights toward an appreciation of the importance of studying the microspatial behavior of individuals, both as an end in itself and for the light it may shed on processes or rationale underlying the evolution of larger landscapes.

One outgrowth of this development is our recognition that man, like other animals, has a distinct set of territorial needs, but unlike most other animals, a special penchant for wider systematic territorial exploration, aggrandizement, and modification. How individual men in different places perceive, cognize and organize the territory through which they move presents a plethora of fascinating questions.

The concept of home range, recently defined by Gelwicks as "that series of linkages and settings traversed and occupied by the individual in his normal activities," (1) appears to have great potential for the study of spatial and environmental behavior and important implications for environmental design". This definition may be too ambiguous for some, but we accept it for the moment as sufficient. In the case of children, we distinguish individual home range as the territory traversed and occupied voluntarily by the child alone or with siblings or peers, and distinct from family or societally imposed ranges, which being involuntary may result in different reactions on the part of the child. Home range may be continuous or discontinuous (depending, perhaps, on mode of locomotion) but generally appears in our culture to evolve from a single compact area for small children to a set of widely separated nodes for adults. Home range may be described verbally or graphically, pointed out on a printed map or air photo, or simply demonstrated by real world tour. While it is our objective to elicit perceptions, it is possible that the air photo method described below may in fact elicit cognized activity space. These ambiguities and problems not withstanding, it is felt that the attempt to operationalize, measure and study the concept of home range should provide some useful insights into the process of environmental learning.

Detailed study of the manner in which the home range of children in a particular culture or place evolves as they develop from infants to adults and determination of the most significant factors influencing this development may provide important insight into environmental learning and the formation of environmental preferences and attitudes of both individuals and groups. Much current physical planning and investment in residential and recreational development is carried out with little knowledge of or apparent concern for the desires or needs of the clientele supposedly being served. (The location and design of public outdoor recreation facilities in cities and towns is perhaps the most blatant example of this.) Critics of the "Spock" generation not withstanding, it can be argued that children in particular are understudied; this is certainly the case in the field of geography. (2)

Of crucial importance here is the development of a corpus of baseline data which describes the areal extent, structure and function of the paths and areas traversed and occupied by individuals or classes of individuals. If such data can be collected in a manner which also sheds some light upon the processes underlying the formation of the interaction systems identified, so much the better. Our concern is focused upon the home range perceived by individuals, because what is sought is the nature of the internalized gestalt or mental map of the environment as distilled by the individual from the more complex totality of the real world.

Review of Relevant Literature

In spite of a fairly impressive body of work carried out by developmental psychologists, sociologists, and anthropologists on childhood development in a wide variety of settings, the work has been largely aspatial with few important exceptions. While Herbert Wright asks the most direct and pertinent question: "What is the territorial range of the child who lives in a metropolitan suburb? On a farm? In an American small town?", he never comes to grip with the questions posed. (3) Piaget and Inhelder address themselves to the formation of abstract spatial concepts in children, but they do not examine real world territorial behavior. (4)

One of Kevin Lynch's early experiments in examining the perception of urban environments entailed interviewing a select sample of some forty college student and adult residents of Boston and Cambridge concerning their childhood impressions of the urban neighborhood in which they grew up. (5) The results indicated a strong bias toward vegetational elements such as lawns and trees as well as other surfaces (pavements and walls), topography, and open spaces.

Edith Cobb postulates that man's inventive genius is in part an outgrowth of children's "speculative play with nature's plasticity," and goes on to imply that general societal provision of environments condusive to such childhoods may be a prerequisite for human survival. (6) Her thesis is based in part on the study of biographical and autobiographical memories of "middle ... childhood, approximately from five or six to eleven or twelve ...". (7)

Terence Lee and Florence Ladd have recently reported research which suggests that graphic representations of "neighborhoods" by both English housewives and black adolescents may in fact be representations of the subjects' home ranges. (8)

While the above cited works generate a number of stimulating ideas and questions, they provide no concrete data concerning the extent or structure of the territorial ranges of individuals. One notable exception is a monograph assembled by Barker and Wright, which goes to the extreme of describing every behavioral episode during a single day in the life of a seven year old boy in a small town in Kansas; but no conclusions are drawn and no comparable data for other individuals is provided for comparison. (9)

Unpublished work by students of Blaut and Stea at Clark and others have focused on play behavior of children in specific locations. (10) While these works do treat some spatial behaviors of interest to us and provide some useful insights into the cultural and physical determinants of the location and nature of play activity, they do not generate the specific comparative data desired, nor do they provide sound or economical research designs for doing so.

Wisner's study of peasant farm children in St. Vincent, W.I., is an important exception and demonstrates the potential usefulness of an ethnogeographic approach to our understanding of the process of environmental learning. (11) In this regard, it should be noted that there probably exists a considerable body of information on home range and environmental learning in the ethnographic literature, but we have not had time to mine it. (12) Such data would, of course, present some problems of comparability for analysis.

Eliciting Home Range: First Try

Inspired primarily by questions raised by Bunge's Detroit work (13) and independent of the literature reviewed above, the senior author developed a simple method for eliciting childhood home range sketch maps and discussion from young adults using the following exercise:

> From memory draw a sketch map of your childhood (ages 6 - 12 yrs.) "turf." By "turf" we mean that area or set of areas which you traversed, occupied, or used with sufficient regularity and assurance that you considered it for all practical purposes to be the proper domain of you and your friends and/or siblings. The sketch should show major and minor paths, activity nodes, and landmarks as well as 'verboten' or danger areas, important barriers and boundaries, and include a legend. Scale and orientation shown may be relative and need not be precise. Then, write a two to four page analysis, exploring the nature of the patterns of movement and activity revealed by your sketch map and their determinants. (14)

The map generated by this exercise is primarily an 'iconic' (as opposed to linguistic) mode of communication, and is especially suited for expressing the spatial and environmental relationships in which we are interested. Important map characteristics analyzed are 1) scale and scale variation, 2) extent of area shown, 3) detail, density and number of elements included in the map, 4) functional structure of elements (i.e. numbers of buildings, natural features, paths, named and unlabled elements, etc.), and 5) orientation. The map projections generated, with the exception of those produced by very young subjects and some of Ladd's black adolescent subjects, are low oblique or vertical and controlled primarily by orientation; we have not analyzed their significance, although they may have some. (15) Appleyard's analysis of differing topological modes of sketch map drawing appears inconclusive, and this characteristic has likewise been ignored by us. (16) A crucial issue is the degree to which such sketch maps represent the individual's mental map of this portion of his or her universe. While Wood (17) points out some major limitations of free-recall sketch maps for urban image study, asking a person to draw a map of his own 'turf' is quite a different task than that of drawing a map of 'the city.' Even if he has never drawn a map before, he knows the spatial relationships within his 'turf' so well that he can easily draw the most important of them. Some nuances may vary according to his mood or involvement with the task, and the season may influence it as well, but we feel that such maps do reflect the most important elements of an individual's home range and how he feels about them.

While the populations sampled have been small and heterogenous, the materials generated do permit us to make some generalizations and suggest some hypotheses for further testing.

I. Scale, detail and density of elements all tend to decrease with distance from the focal center of the map (most commonly the individual's home and often distinct from the geometric center of the map). This is demonstrated by Figure 1, where the real world distance to school is more than twice the distance to the end of Whitney Drive. Hypothesis: A distance decay function regulates children's interaction within their home range and this is reflected in their sketch maps. Questions for further investigation may concern themselves with the nature of the slope of these scalar variations and how they vary according to age, sex, extent of range and other variables.

While the sketch maps elicited are not to scale, the scale distortions can readily be determined for any area where good topographic or cadastral maps or air photos are available. The scale distortions may provide important insights into the attitudes which individuals hold regarding portions of their home range, and also serve as a diagnostic tool in personality assessment as suggested by Ladd. (18)

II: A number of the maps collected to date, particularly a recent developmental sequence collected from students at Eastern Washington, clearly demonstrate the dynamic nature of home range, especially its extent and functional structure. The work of Walstrom and Zerner and Wisner also support this. (19) General hypotheses: A. The extent and functional structure of home range varies according to age, sex, mobility, settlement density, land use, parental control, and cultural or societal norms; B. Individuals have distinct personal, peer group, and family group ranges; C. While individual and peer group ranges correspond closely, the sketch maps generally represent the former. The nature and determinants of home range extent and its functional structure presents the most complex and intriguing set of questions in our opinion. Despite the limitations and caveats noted above, the 'turf'

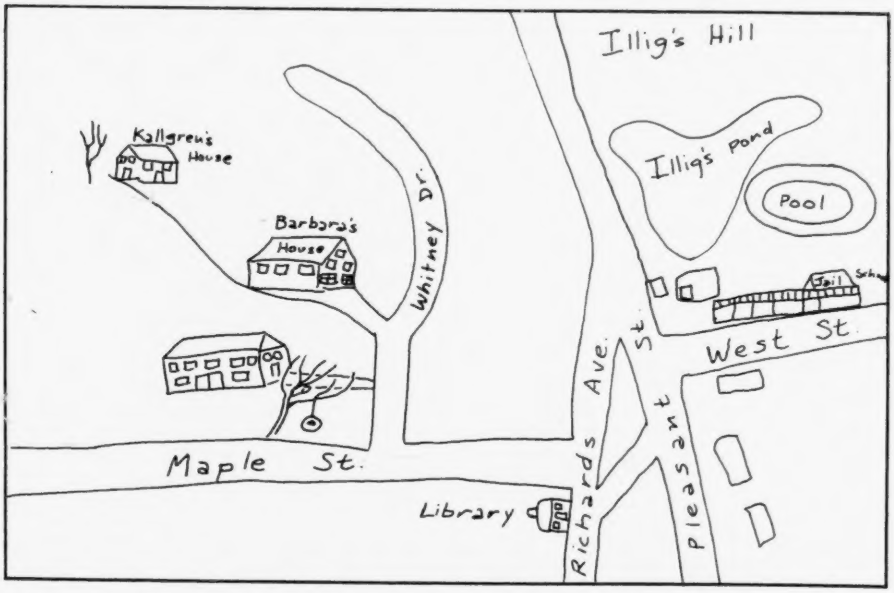

Figure 1. 'Turf' Map of Twelve Year-old Girl - A New England Town Center

maps show a fascinating richness of local detail and clearly demonstrate that every individual is indeed an expert on the geography of his or her own microcosm, a fact that many planners fail to recognize or utilize in their work.

III. The orientation of home range maps are highly varied and seldom compass (north) oriented. Hypotheses: A. Orientation tends in the direction of the most important element(s) in an individual's home range (i.e. downtown); or B. Orientation tends to lie in the direction of the primary path leading away from home. We may be way off base on this set of hypotheses and orientation may, in fact, prove to be a relatively unimportant characteristic of home range.

How can such complex and highly individualized documents as these be usefully analyzed and compared? A major need is to sample a number of distinct population groups, each of which is as homogenous as possible with respect to age, socio-economic, cultural and environmental background. (20) The free-recall sketch map requested should focus upon the present situation with respect to time (and with an awareness of the problem of seasonal variation and bias), and, if possible, be coupled with a formal questionnaire or interview wherein the various settings and persons included in the home range are described with regard to function and ranked in terms of relative importance, and other relevant background data also obtained. From these materials, data matrices of the incidence, frequency and relative importance and location of elements within the home ranges may be obtained. Group means, variances, indices, and descriptive models may be obtainable which would then permit between-group comparisons and analyses.

Eliciting Home Range: An Experiment (21)
As a result of the promise and interest aroused by the trials described above, it was decided to see if it would be possible to elicit more accurate home range data from elementary school children. Here we had virtually no prior experience to draw upon, but derived our major inspiration from the recent research of Blaut and Stea which indicates that five, six, and seven year old children may read and map from aerial photographs. (22)

Since the junior author had prior teaching experience in an elementary school in Baltimore, it was decided to use second and fourth graders from both an inner city school in Baltimore and a suburban school (Ann Arundel Co.) as subjects. The grade separation was elected to provide developmental data, and the locations were chosen to provide environmental contrast. In order to minimize within group variation and preclude ethnic variation, only black children were tested. A total of one hundred subjects all living within walking distance of each school and evenly divided according to sex and grade were selected for testing. Preliminary pilot testing led to the following procedure:

Each child was interviewed separately by the junior author, and in turn: a) introduced to a small scale photo of his neighborhood, b) given a large scale photo of his neighborhood (1:1332 for the urban area; 1:2064 for the suburban area) with a frosted acetate overlay, c) oriented to the photo and instructed to locate in turn 1) his house or apartment building, 2) his school, 3) the residences of his best friends, 4) play areas frequented, 5) areas where bikes were ridden and paths commonly walked within the neighborhood, 6) any areas of fear or avoidance. While the child indicated all these with his finger, the interviewer marked the designated activity nodes and paths on the acetate overlay with colored felt tip pens for later measurement.

While this procedure contrasts sharply with the original method of eliciting free style maps, it was chosen as the most simple and expedient means of overcoming the motor skill and conceptual problems encountered by young children in drawing maps. (23)

From the overlay drawings, it was then possible to measure total non-redundant path length, and to count and classify activity nodes as either educational (school), social (friends' residence), recreational (play area) or commercial (store or commercial recreation, cinema, bowling alley, etc.). No areal measurement was attempted since it was assumed that the total path length provided a less ambiguous and more easily derived surrogate measure of home range.

Group means derived from the measures of path length yielded the results shown on page 1-1-5 (Table 1). The range of boys in every case is substantially greater than of girls, and the fourth grade boys' range appears to be significantly greater than that of second grade boys. What is more surprising, however, is that urban-suburban differences in range, though extant, are not as great as one might expect in light of the settlement density differences and the average distance between home and school. It appears that the differences are accounted for to a substantial degree by the fact that a higher percentage of suburban children have bicycles, probably due to higher average family income. Most surprising is the absences of any difference between the mean range of second and fourth grade suburban girls, and the fact that the second grade suburban girls without bikes had a greater range than those with bikes, although these and other anomalies in the data may have arisen simply as a result of small-sample bias.

The functional structure of activity nodes identified by the children is graphically summarized in Figure 2. Here the data on total number of activity nodes for the urban sample provides fairly solid evidence of increasing size and complexity of home range. But as in the case of the path length data, the data for the suburban group, especially the girls, is surprisingly ambiguous, and fails to reflect as orderly a progression as the urban data. One possible explanation may be that suburban back yards are simply more sufficient play areas than the sidewalks and vacant lots of the central city, hence the suburban children seek fewer activity nodes. The structural data appear to support this explanation as it can be seen that the increase in the average number of recreation nodes accounts for about half the increment in total activity nodes for the urban children, while no such incremental trend occurs for the suburban children. Differences in parental control or in 'opportunity surfaces' (24) in these two environments, however, may also provide possible explanations for the differences in numbers and functional structure of activity nodes observed.

Given the limited sample size and the limitations placed upon the interview for operational

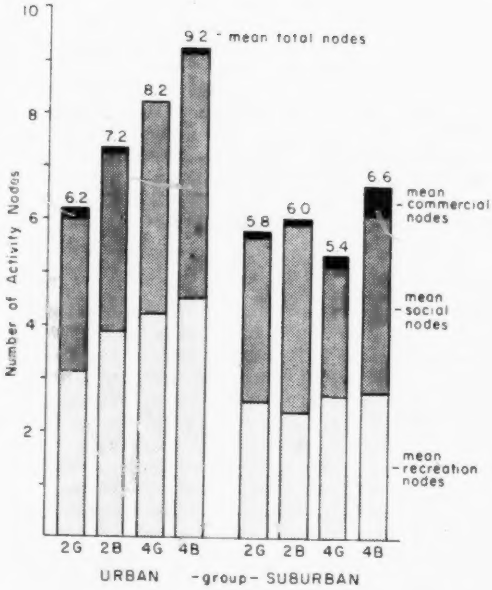

Figure 2. Functional Structure of Activity Nodes

Table 1: Mean Home Range and Bicycle Ownership of Black Elementary School Children*

Subgroups	Total No. Children in Subgroup	Mean Home Range of Subgroup	No. Bike Owners	Mean HR of Bike Owners	No. Non-Bike Owners	Mean HR Non-Bike Owners
Urban						
2nd Gr. Girls	12	2833	7	2930	5	2699
2nd Gr. Boys	13	4131	5	5432	8	3315
4th Gr. Girls	13	3518	7	3811	6	3175
4th Gr. Boys	12	5816	9	6828	3	2779
All Urban	50	4074	28	4850	22	3064
Suburban						
2nd Gr. Girls	12	3962	9	3667	3	4848
2nd Gr. Boys	13	5209	12	5234	1	4902
4th Gr. Girls	13	3905	9	4107	4	3451
4th Gr. Boys	12	6165	9	6820	3	4200
All Suburban	50	4810	39	4978	11	4168

* Mean Home Range, given in feet, represents total non-redundant path length.

reasons, no statistical tests of significance have been applied and the conclusions are only tentative. On the other hand, it is felt that the basic methodology recommends itself to further refinement and use, given its simplicity, ease of replication and potential for cross cultural application and comparison. If carefully administered, the method should lend itself particularly to an examination of hypotheses which may be elaborated out of general hypotheses II A., II B., and II C. discussed pages 1-1-3 and 1-1-4.

Summary and Conclusions

While the concept of home range applied to social research is of relatively recent vintage, it should be apparent that variations in its size, shape, orientation, structure and development generate a wide range of significant questions for the behavioral investigator. Applicability of research on home range characteristics to problems of environmental design has been alluded to and should be obvious. Two experimental methodologies for eliciting home range data have been described and some analyses suggested. It is hoped that other researchers will join us in expanding the research and applications of this concept.

Acknowledgements

Annette Buttimer, Jim Blaut, Ken Craik, George McCleary, David Stea, Denis Wood, Roger Hart, Gary Moore and Leonard Mark as well as many students at Clark University and elsewhere, have provided good ideas, constructive commentary and valuable data for the work reported here. The careful critique of an earlier draft by Graham Rowles and Bob Colenutt has proven especially helpful in sharpening our focus.

Notes

(1) Gelwicks, L.E., "Home Range and Use of Space by an Aging Population," in: Pastalan, L.A., and Carson, D.H. (eds.), Spatial Behavior of Older People, (Ann Arbor, Michigan: Institute of Gerontology, University of Michigan - Wayne State University, 1970), p. 149.

(2) Bunge, W., "Field Notes, the First Years of the Detroit Geographical Expedition: A Personal Report," The Detroit Geographical Expedition Discussion Paper (Detroit: The Society for Human Exploration, 1969), p. 27.

(3) Wright, H.F., Recording and Analyzing Child Behavior with Ecological Data from an American Town (New York: Harper and Row, 1967), p. 3.

(4) Piaget, J. and Inhelder, B., The Child's Conception of Space (New York: W.W. Norton, 1967).

(5) Lukashok, A.K. and Lynch, K., "Some Childhood Memories of the City," Journal Amer. Inst. of Planners, Vol. 22 (1956) pp. 142-152.

(6) Cobb, E., "The Ecology of Imagination in Childhood," (Daedalus, Vol. 88 (1959) pp. 537-548) reprinted in: Shepard, P. and McKinley, D. (eds.) The Subversive Science: Essays Toward an Ecology of Man (Boston: Houghton Mifflin Co., 1969) pp. 122-132.

(7) Ibid., pp. 123-125.

(8) Ladd, F.C., "Black Youths View Their Environment: Neighborhood Maps," Behavior and Environment, Vol. 2 (1970) pp. 74-99, and Lee, T., "Urban Neighborhood as a Socio-Spatial Schema," Human Relations, Vol. 21 (1968) pp. 241-268; reprinted in Proshansky, H.M.; Ittleson, W.H., and Rivlin, L.G. (eds.), Environmental Psychology: Man and His Physical Setting (New York: Holt, Rinehart, and Winston, 1970) pp. 349-370.

(9) Barker, R.G. and Wright, H.F., One Boy's Day, (New York: Harper and Row, 1951).

(10) Bloom, J., "A Microgeographic Study of Children," in Stea, D. (ed.), "Working Papers in Place Perception, 1969," Place Perception Research Report Number 2 (Clark University Worcester, Mass., 1969), pp. 29-44; Garside, C. and Soergel, M., "Children's Environmental Perception and Behavior in a City Park," in Ibid., pp. 53-85; Wahlstrom, S., "The Geography of Children's Outdoor Play," (Unpublished paper, Department of Geography, Wayne State University, Detroit, 1969) and Zerner, C., "Study of Play Behavior of the Children of St. Vincent," (Unpublished paper, Place Perception Project, Clark University, Worcester, Mass., 1971).

(11) Wisner, B., "Learning to be a Farmer in St. Vincent, W.I.," (Unpublished paper, Place Perception Project, Clark University, Worcester, Mass., 1970).

(12) The work of the child psychiatrist, Robert Coles, is also strongly supportive and suggestive for the work reported here; see Coles, R., "A Domain or Sorts," Harper's, (Nov., 1971), pp. 116-122; and ___________, Children of Crisis: A Study of Courage and Fear, (Boston, Little, Brown and Co., 1967).

(13) Bunge, op. cit., passim.

(14) To date, this exercise has been administered to more than 100 college graduate and undergraduate students, and in modified form to approximately 40 younger students (ages 6-16).

(15) Ladd notes that some of her subjects produced neighborhood sketches from a horizontal perspective, (although most drew more conventional sketch maps) and implies that these differences in projection may have some cognitive significance, but she fails to elaborate as to what it might be other than a failure to understand the assigned mapping task. (Ladd, op. cit., p. 83).

(16) Appleyard, D., "Styles and Methods of Structuring a City," Environment and Behavior, Vol. 2 (1970) pp. 100-117.

(17) Wood, D., Unpublished dissertation proposal, (Graduate School of Geography, Clark University, Worcester, Mass., Sept. 1971) pp. 2-3. Appleyard's work cited in the note above provides strong corroboration for Wood's assertions.

(18) Ladd, op. cit., p. 98.

(19) Wahlstrom, op. cit., pp. 4-11; Zerner, op. cit., pp. 8-9, 16-18 and graph 1A; and Wisner, op. cit., pp. 3-6.

(20) Denis Wood's monograph, dealing with adolescent images of a Mexican town, clearly demonstrates the value of the large scale homogenous sample approach to a problem of this nature: Wood, D., Fleeting Glimpses (Worcester, Mass., Denis Wood's King Street Publications, 1971).

(21) The data and discussion in this section are drawn primarily from the junior author's M.A. thesis: Tindal, M., "The Home Range of Black Elementary School Children: An Exploratory Study in the Measurement and Comparison of Home Range," (Unpublished thesis, Graduate School of Geography, Clark University, Worcester, Mass., 1971).

(22) Blaut, J.M. and Stea, D., "Studies of Geographic Learning," Annals, Association of American Geographers, Vol. 61, (1971) pp. 387-393.

(23) An alternative approach to overcome the motor skill problem encountered by younger children in mapping would be to provide them with plastic materials (such as modeling clay or a sand box) and/or three dimension materials which can be freely manipulated (building blocks, toy cars, etc.) thus permitting them to make models of their home range area. In addition, an ideal procedure would be to have subjects model or draw their home range first and then point it out or trace it out on a large scale air photo.

(24) Wood has defined opportunity surface as "a cartographic composite and rendering of mental maps elicited from subjects on which one aspect of their experience manifests itself." (Wood, Fleeting Glimpses, op. cit., p. 129.) An example of such a surface might be vacant lots good for playing football. Of course, for such surfaces to manifest themselves in mental maps, they must be perceived and exist in the individual's real world. A careful study of many newer suburbs, lacking vacant lots, alleys, small stores and sidewalks, may, in fact, reveal them to be impoverished environments from the standpoint of children.

THE HOME AREA CONCEPT IN URBAN ANALYSIS: THE USE OF COGNITIVE MAPPING AND COMPUTER PROCEDURES AS METHODOLOGICAL TOOLS*

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In recent years the problems of the cities have come to the forefront of research in a number of disciplines (e.g. Geography, Psychology, Sociology and Urban Planning). Much of this work has been generated as a result of the ideas of a number of 'anti-urbanists', such as Lewis Mumford (1) and Louis Wirth (2), who contribute to the thesis that the present urban way of life is detrimental to man's physical, social, and psychological well being. In addition, much has been written by authors who believe that such a state of affairs is not the case, or if it is so, it need not be in the future. In this second group there is an important division between those, such as Catherine Bauer (3), who oppose what might be termed the 'neighborhood principle,' and others, such as Doxiadis (4), who support it.

The Urban Neighborhood

The reasons for, and characteristics of, this division are important, because the features, advantages and disadvantages attributed to the neighborhood are surprisingly similar to those discussed by Wirth and Mumford with reference to the larger urbanized area—the city.

It has been well documented, since Park's initial observation, that in the urban area secondary relationships among people have multiplied at the expense of primary relationships, and that "in the city environment the neighborhood tends to lose much of the significance which it possessed in simpler and more primitive form of society" (5). At least for some groups within the urban area, the neighborhood unit seems at present to be superfluous, and probably nonexistent as an arena of intensive social interaction and socialization. This is not to deny that in the past its role was an important one, and, indeed, may still be a viable one for groups such as poor whites, or minorities (6). It is simply to recognize that the change has taken place.

McClenahan, noting this change in the functions of the neighborhood, differentiated between the geographical divisions of the city, which are a function of the utilization of space, and the psycho-social divisions, which stem from associations between people (7). She suggested that nigh-dwellers, who live in a geographical division, should be separated from neighbors, who interact within a psycho-social division. In these terms, the neighborhood unit no longer appears to act as a psycho-social division for all groups; the question remains as to whether or not it is still a geographical division. Is there a local division of space based on the utilization of the city? And, perhaps more importantly, does such a division have any meaning? Is it a question of "the neighborhood is dead: long live the neighborhood"?(8)

The concept concerning the psycho-social significance of the neighborhood will not be discussed here. Rather, the idea of geographical divisions will be analyzed, involving as it does the problems of territoriality and meaning within the urban sphere; problems currently of great importance in the fields of urban geography and urban planning, and central also to the differences between Wurster and Doxiadis.

Territoriality in the City

Ardrey has argued that the territorial imperative "is the biological law on which we have founded our edifices of morality," and that it is still present today (9). Dubos has pointed out the importance of territoriality with respect to the stresses and strains of modern life (10), and Milgram, extending the same line of thought, has put it into a more directly urban context (11). He points out that a link must be made between the demographic circumstances of urban life, and the individual's experience within the city.

It is postulated here that it is at the level of the individual and his territory that the neighborhood principle, albeit in a different guise, must be reevaluated within urban studies—as a measure of one aspect of the meaning of urban life for an individual or a group of individuals. As Soja points out, "the existence of recognized and named neighborhoods; areas of homogeneous and segregated residential patterns and ethic, religious, and occupational composition; and pronounced barriers and boundaries to human interaction which are not solely based on physical features all attest to the continuing operation of powerful local territorial mechanisms in the modern urban context" (12).

The Community within the Urban Area

It is important now to differentiate more thoroughly between 'community' and 'neighborhood,' two very different concepts that are often taken to be synonymous. In essence, both concepts have been used as a means of evaluating the pattern and depth of social relationships in space; but the former concentrates on the problem from the viewpoint of human behaviour, whereas the latter is more completely spatial in its usage. As Lee points out the combination of the two elements has been an elusive exercise in the past (13). These two elements, territory and social relationships, may be crucially interdependent, but it seems necessary to look at them in isolation.

The problem has recently been extensively reviewed from the neighborhood point of view (14), but the meaning of 'neighborhood' remains ambiguous. For instance, it might mean very different things even for people who are socioculturally very similar (15). Lee attempted to solve this problem by getting respondents to draw their neighborhood "and to describe in detail their behaviour in the immediate environment" (16), but still the problem of terminology remained. The people might have meant the block or two in which they live and meet neighbors, or they might have been describing some form of larger community.

Community is itself a loaded term, as it may or may not refer to some continuous spatial unit, as in the more traditional use of the term. McClenahan suggested many years ago that the word communality should be substituted as a term for primary group without local territorial attachment (17), (although perhaps with multiple territories which serve some of the purposes of this local territorial attachment).

Webber took up this idea (18), suggesting that the less confusing terminology of 'community without propinquity' should be adopted to deal with the phenomenon he later dubbed as the 'nonplace urban realm' (19).

The work of Janowitz has also examined the extent to which people have attachments to the area around the home. He suggests that certain groups have only limited liability to this nigh-dwelling group of people, and that the extent and character of an individual's attachments to this group "are limited in the amount of social and psychological investment they represent" (20).

Despite this new line of research, many planners and social scientists still talk about 'communities' as always being spatially continuous areas containing integrated social behaviour. If, however, the communality and the community of limited liability are the important sets of relations in the city today, for certain socio-cultural groups, then for these groups the traditional community is relatively meaningless and very confusing as a guideline for environmental design. It would seem to be more important to discover how the social and psychological investments of an individual are represented in terms of the local area around the home; and if there are any important regularities in these investments. In other words, given that people live in communities which have only limited liability, are there any regularities in the spatial expressions of these communities, as conceived by their inhabitants?

The Home Area Concept

In this research an attempt has been made to break from the more traditional terminology regarding the local area (outlined above), and adopt the idea of 'home area,' a concept suggested by Stea (21). This term is one which has an obvious spatial dimension—the area around the home—but also, a cognitive meaning —an area of importance or significance around the home—that might be comparable from person to person. Thus the home area of an individual is the area around his house in which he feels most at home, and this is a direct function of the utilization of the space around the dwelling unit. Some of this spatial utilization might be a result of social interaction, but this is not the most important variable with which we are concerned. Thus the home area concept is a directly geographical one, but with economic and psycho-social overtones. The use of this concept is not meant to be particularly novel, but it is employed in order to sidestep some of the confusion generated by the older terminology.

In this paper we report the results of one part of a lengthy questionnaire dealing with various aspects of the social space of a group of urban residents. Particularly it deals with the results of one cognitive mapping question, in which the respondents were asked to outline their home area on a base map. This was used in conjunction with other questions concerning the home area. One of these was a relatively extensive map question in which the respondents were asked to spend some time drawing the features of the home area they considered to be "distinctive, interesting and important," either as a map or as a list (22). These other questions were asked prior to the question reported on here, and enabled the respondent to cognitively identify the concept, before they were asked to put boundaries around it. We do not presume to have solved the problem of terminology, as it is still possible that different people mean different things by this new term. We are, however, proposing that we have avoided many of the biases of previous research in attempting to delineate an area around the home that has meaning to the individual. If respondents asked for further guidance, they were referred back to their original map, and were also told to outline the area in which they felt "most at home."

Lastly, although the map given to the respondents was of a restricted area, instructions were given to the effect that the restriction should not determine the response to the question. That is, the respondent was told that he (or she) could draw boundaries outside the area of the map, where appropriate; the only constraint being that a continuous shape be enclosed. Although the majority drew rectangular areas, this was not always the case, and there were some that were elliptical and polygonal. Twenty percent of the husbands and twenty-eight percent of the wives drew at least one section of the boundary 'outside of' the map.

The Sample

The respondents (husband-wife couples) were chosen, using a systematic random sample design, from one census tract in the Mar Vista area of Los Angeles; a predominantly middle class residential area to the east of Santa Monica. The tract was chosen from a social area analysis of Los Angeles prepared at U.C.L.A. (23). The selective criteria were that the inhabitants possess (on the average) a high enough education and income level to satisfy the requirements hypothesized by Webber for 'nonplace' people (24)—that is to say, they had the opportunity of being 'nonplace' people by reason of their freedom from certain restraints, such as an inability to move freely about the urban area, or a lack of knowledge of other areas to go to. Thus the sample is not meant to be representative of urban life in general, but representative of one subculture within the urban area. Results indicate that this procedure was valid for choosing the sample, despite the problems inherent when dealing with aggregate data. The average income of the sample was between $15,000 and $18,999 with only 15.3% giving their income as below $11,000; the average educational level was 'some college' with only 3.1% of the husbands and 7.7% of the wives not having at least completed high school. Residential stability and some integration into the area (through children) were also factors involved in selection of the group. In this sample, 86.2% of the husbands had lived in the area for more than three years, and 81.6% of the wives had done so. Of the respondents, 54% had children (under eighteen years old) living at home, and a further 21.5% had previously had children whilst living in the area. Thus the criteria were satisfied, and the sample group represented those whose contacts might either be in communalities, with limited liability to the local area, or in neighborhoods with important commitments to local area. In terms of the home area concept, the group had the possibility of either possessing a large or a small home area, depending upon their personal commitment. It is also important to note that 89.2% of the couples had access to two cars, and 98.5% had access to at least one.

As pointed at above, married couples were interviewed, with each husband and each wife completing a separate questionnaire. The original sample was 164, out of which 114 'qualified' as married couples; out of these 65 couple-interviews were obtained. One husband and one wife gave uninterpretable answers to the home area map question, leaving 64 of each for this study.

The census tract itself is almost completely residential, although there are shops at three corners. Single family residences comprise 80.0% of the dwellings, the balance being apartments. It is located quite centrally within western Los Angeles, enjoying easy access to two major freeways, and to a large variety of urban centres (such as Beverly Hills, Santa Monica, and Venice). Therefore, although the tract itself is limited as regards land use, the potential 'home areas' could include a wide variety of social, cultural, economic and recreational activities.

The Hypotheses

Firstly, it was hypothesized that there is an area around the home with meaning for the individual, and that this area can be delineated by a cognitive mapping procedure. The area was pre-defined by the respondent, with guidelines provided by the researcher. (See above)

Secondly, it was hypothesized that there would be recognizable differences and similarities within the delineations, especially with regard to area and boundaries. There was expected to be a difference between husbands and wives in terms of the areas delineated, and in terms of the proportions designating any particular boundary.

Differences between husband and wife, as regards 'home area' definitions, were expected to arise as a result of their role differences.

More precisely, it was hypothesized that females would delineate a larger 'home area' than the males, as their role calls for a greater level of involvement both qualitatively (in terms of behaviour) and quantitatively (in terms of time) in the area about the home. The implicit significance of this hypothesis is that, although it recognizes the need for, and existence of, some established territory for an individual, it makes the assumption that the size of this territory can be socially and culturally influenced. Results show that the basis for this hypothesis was valid, as 66.1% of the wives did not work, compared to 6.2% of the husbands; and of this latter group only one individual had never worked while living in the area.

Thirdly, it was hypothesized that there would be a directional bias in the home areas, based upon the utilization of space in the city; and that this bias might also differ from husbands to wives. Descriptive statistics were used to demonstrate the validity of the first two hypotheses, and a computer mapping procedure, combined with visual comparison, was used to investigate the third hypothesis.

The base map for the computer procedure was constructed in such a way as to reveal elements of both distance and direction. This was done by drawing a series of ten concentric circles, at half mile intervals from the centroid of the study area, and super-imposing on this sixteen sectors radiating outward from the centroid. Thus there were one hundred and sixty gridded zones into which a home area could fall, and each zone that contained any part of a home area was included.

The computer mapping procedure consisted of the use of a Symap technique; a method of producing maps which graphically depict spatially disposed qualitative and quantitative information. This enabled the data to be portrayed accurately and in a manner amenable to comparative analysis. More particularly, a pair of contour maps was produced. This type of map "consists of closed curves known as contour lines which connect all points having the same numeric value or height. Contour lines emerge from a datum plane at selected levels which are determined from the scale of the map and the range of the data. Between any two lines a continuous variation is assumed" (25).

Results

a) Home Area Definition

All but two respondents were able to define a 'home area' using the methods outlined above, and only one of these two could not define an area. Not only were they able to define areas, but the similarities between the definitions indicates that the respondents were delineating areas that had at least some coincidence of meaning. There is also evidence that the size of the area defined by the two groups differs, although existing methods do not allow us to determine the exact extent of the difference in any conclusive way.

The evidence for such a difference is fourfold. Firstly, the areas designated by wives were larger than those of husbands, with medians of 1.3 square miles and 0.7 square miles respectively. Secondly, 28% of the wives, as against 20% of the husbands, drew at least one of their boundaries off the map. Thirdly, in 56% of the sample the wives' maps were larger than their respective husbands' maps, as against 41% of the cases where the reverse was true. The remaining 3% were the same. Fourthly, there is visual evidence from the maps that the wives' areas are larger; especially at the second level (see Figs. 1 & 2).

b) Home Area Boundaries

Nearly all respondents used roads as boundaries for their 'home areas,' and thus there were considerable grounds for comparability. The roads of this part of Los Angeles generally form a regular grid pattern, and on two sides, the south and west, there were important boundaries for both husbands and wives (see Table 2). On the north and east there was much more confusion in terms of overall boundary delimitation, although once again there were some significant areas of agreement. The fact that there were similarities is especially interesting as some previous research undertaken in Britain found that at the neighborhood level "each person's constellation of experience and action is apparently unique, although there is some evidence of norm formation" (26). It would appear that 'home area' can be more consistently defined in this American example, possibly because the environmental clues give rise to more significant boundaries in this urban area. More particularly, the road-plan and pattern of road use gives rise to a clearer 'mental image' in terms of boundaries. This supposition agrees with Lee's conclusion, "that concordance on the prominent boundaries. . .would be closer if the boundaries were accentuated. . . (for instance, if). . . traffic roads. . .could be used to delineate subunits" (27). The present results do not appear to be unique, as the application of the questionnaire in Brentwood, an upper middle class area of Los Angeles with essentially no grid pattern as regards the streets, is producing essentially similar results (28).

TABLE 1. THE SIZE OF THE HOME AREA (IN SQUARE MILES)

		0-1	1-2	2-3	3-4	4-5	5-6	6-10	11-19	20+	
% of sample	husbands	53.1	21.9	7.8	3.1	0.0	6.3	0.0	0.0	7.8	= 100.00
	wives	45.3	21.9	9.4	1.6	3.1	3.1	6.3	6.3	3.1	= 100.20

TABLE 2. THE BOUNDARIES OF THE HOME AREA*

BORDER	BOUNDARY NAME	NUMBER OF GROUP AGREEING	
		HUSBANDS	WIVES
East	Barrington Avenue**	4	5
	Sawtelle Blvd. (0.5 miles to the east)	13	14
	San Diego Fwy. (0.6 " " " ")	7	8
	Sepulveda Blvd (0.7 " " " ")	6	13
	Overland Ave. (1.3 " " " ")	5	8
	Other	6	6
North	National Blvd. **	19	21
	Pico Blvd. (0.8 miles to the north)	9	8
	Olympic Blvd. (1.0 " " " ")	0	5
	Wilshire Blvd. (approx. 2.2 miles to the north)	2	9
	Sunset Blvd. (approx. 3.5 miles to the north)	4	0
	Other	10	11
West	Bundy/Centinela**		
	Pacific Ocean (approx. 2.6 miles to the west)	31	31
	Other	6	3
South	Palms Blvd.**	16	15
	Venice Blvd. (0.6 miles to the south)	24	28
Within the Census Tract	a) Total area within the census tract	20	15
	b) One boundary within the census tract:		
	(i) Inglewood Blvd.	4	10
	(ii) Other	5	3

* As a respondent may not have drawn a rectangular home area, the totals do not add up to the same amount in each group.

** Boundaries of the census tract.

All the boundaries chosen with any great frequency (see Table 2) were major through streets, and in most cases they were the closest such streets to the study area. The number of streets chosen as boundaries in any direction can be taken as an index of agreement or confusion, as the case may be. The fact that in most cases both husbands and wives chose the same order of streets as being important, shows that there is a considerable amount of cognitive agreement involved, although the different groups defined areas of different size.

It is also important to note that freeways were infrequently chosen as boundaries. The San Diego Freeway (running approximately north-south) was chosen by only 12% of the respondents, and the Santa Monica Freeway (running diagonally across the grid pattern to the north of the area) was chosen by only 3% of the respondents. The reasons for this are not entirely clear, however in this area of Los Angeles the San Diego Freeway is well landscaped, and is not a significant barrier to communications. As a result, it may not have a strong boundary effect, except for frequent users. The Santa Monica Freeway, as mentioned above, cuts across the general road pattern and is thus a source of confusion in terms of location. In addition, it has no offramps between Overland Avenue and Beverly Drive, the area directly to the north of the study area, and so its presence is not reinforced. Thirdly, it is elevated along this particular stretch and is neither a visual or physical barrier for most of its length, despite having obvious effects upon land use.

c) Distance and Direction

The importance of the western and southern boundaries is emphasized by the evidence of directional bias towards the north and east (see Figs. 1 & 2). This bias was different for husbands and wives, and the reasons for this are to be found in an examination of the behaviour in space of both groups.

Both wives and husbands show a bias to the north, east, and south at the third and fourth levels. At the second level, however, there is a difference in the pattern. The husbands show a significant bias to the east and north (see Fig. 1). The wives show a similar pattern to the east and north, but also include a significant area to the west (see Fig. 2).

At this point, only tentative explanations can be offered for these findings. The major lines of communications in west Los Angeles are east-west roads, running from the coast to downtown Los Angeles. This is reflected in the easterly bias. In addition, many of the facilities used by the respondents lie on these routes. The question of facilities is especially pertinent, as the wives' bias is towards the important shopping and entertainment areas of Westwood, West Los Angeles, and the shopping area of Santa Monica. The husbands' bias towards the north is also towards Westwood and West Los Angeles; the lack of any significant bias towards the west indicating that there are differences in the utilization of space within the family group. This lack of penetration westwards is surprising, however, due to the close proximity of the ocean. It might be partially explained by the barrier effects of Santa Monica Airport and Venice, a lower class and ethnic 'slum' area avoided by many people of the class and status level interviewed.

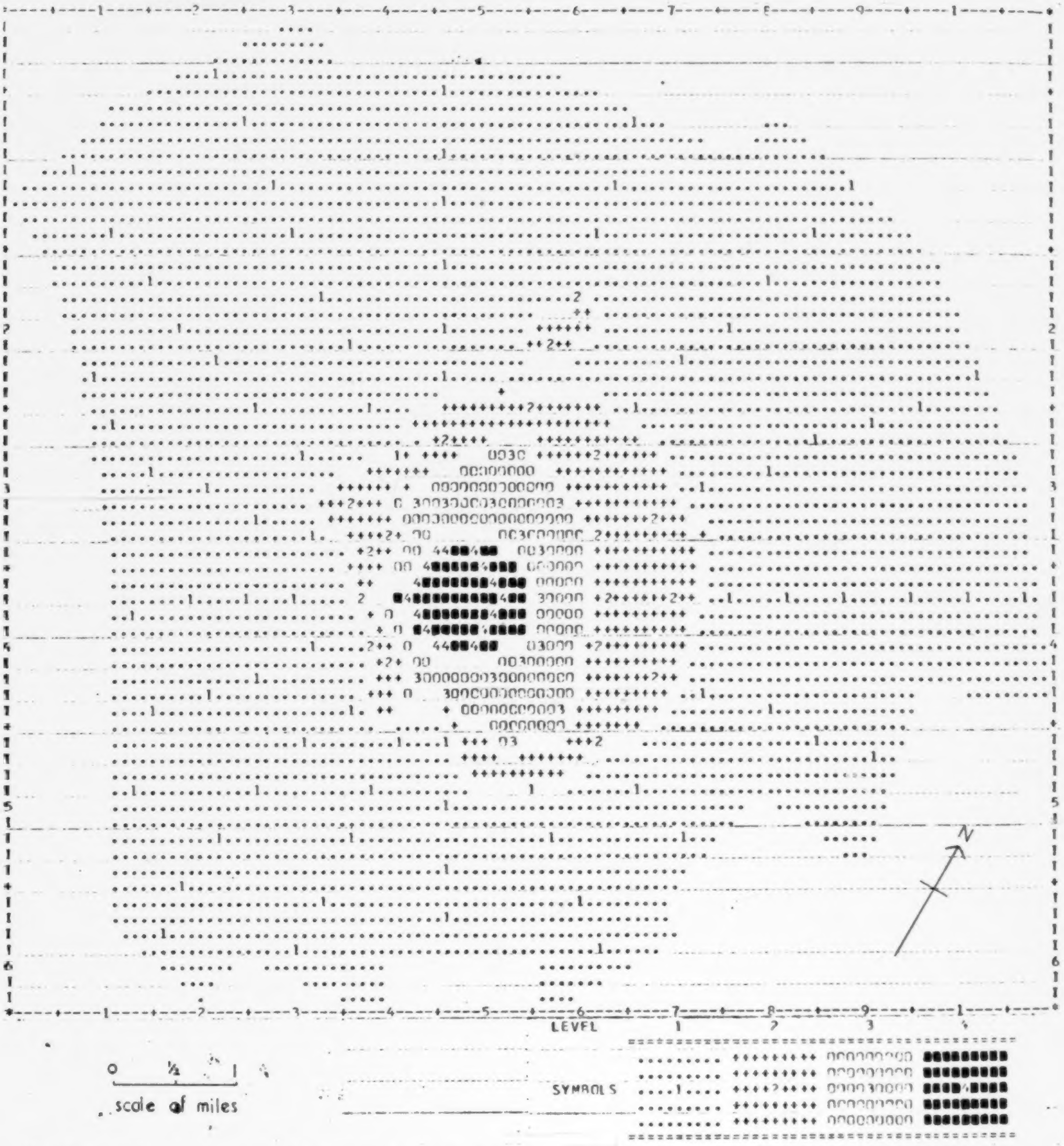
There are some north-south lines of communication that are important, such as the San Diego Freeway and Sepulveda Boulevard, but these are proportionately fewer than the east-west roads. In addition, to the south is Los Angeles International Airport, a low-lying area occupied in parts by Marina del Rey, Hughes Airport and Ballona Creek, and Baldwin Hills. It is not suggested that the existence of these areas curtails the 'home area' per se, but rather that they curtail the communication and interaction patterns that contribute to the construction of 'home areas' in the minds of the respondents. In addition to the physical barriers that these areas present, all are zones containing confusing road patterns. Respondents noted getting lost in them, and thus they are unlikely (by definition) to be areas in which one feels at home.

Conclusions

Although the concept of 'home area' is a viable one, it does not answer all of the problems alluded to earlier. The wide range of area-size for both husbands and wives might be a true indication of differing home areas. It might also mean that they are trying to define different cognitive ideas in our terminology.

Our hypotheses have generally been supported by the data. We hypothesized that there would be differences, and there are, but how important are these for theory and planning? In our opinion these results have clear significance in terms of planning at the 'neighborhood' scale within the urban area. To return to the discussions of Bauer and Doxiadis, it would appear that the former is most correct in her assumptions, although the latter's point of view cannot be dismissed. Although the average home area was 0.7 square miles for husbands and 1.3 square miles for wives, 31% of the former group and 23% of the latter outlined their 'home area' completely within the census tract, an area of less than half of one

FIGURE 1. HUSBANDS HOME AREA MAP : SHOWING PERCENTAGE OF HOME AREA AGREEMENT.

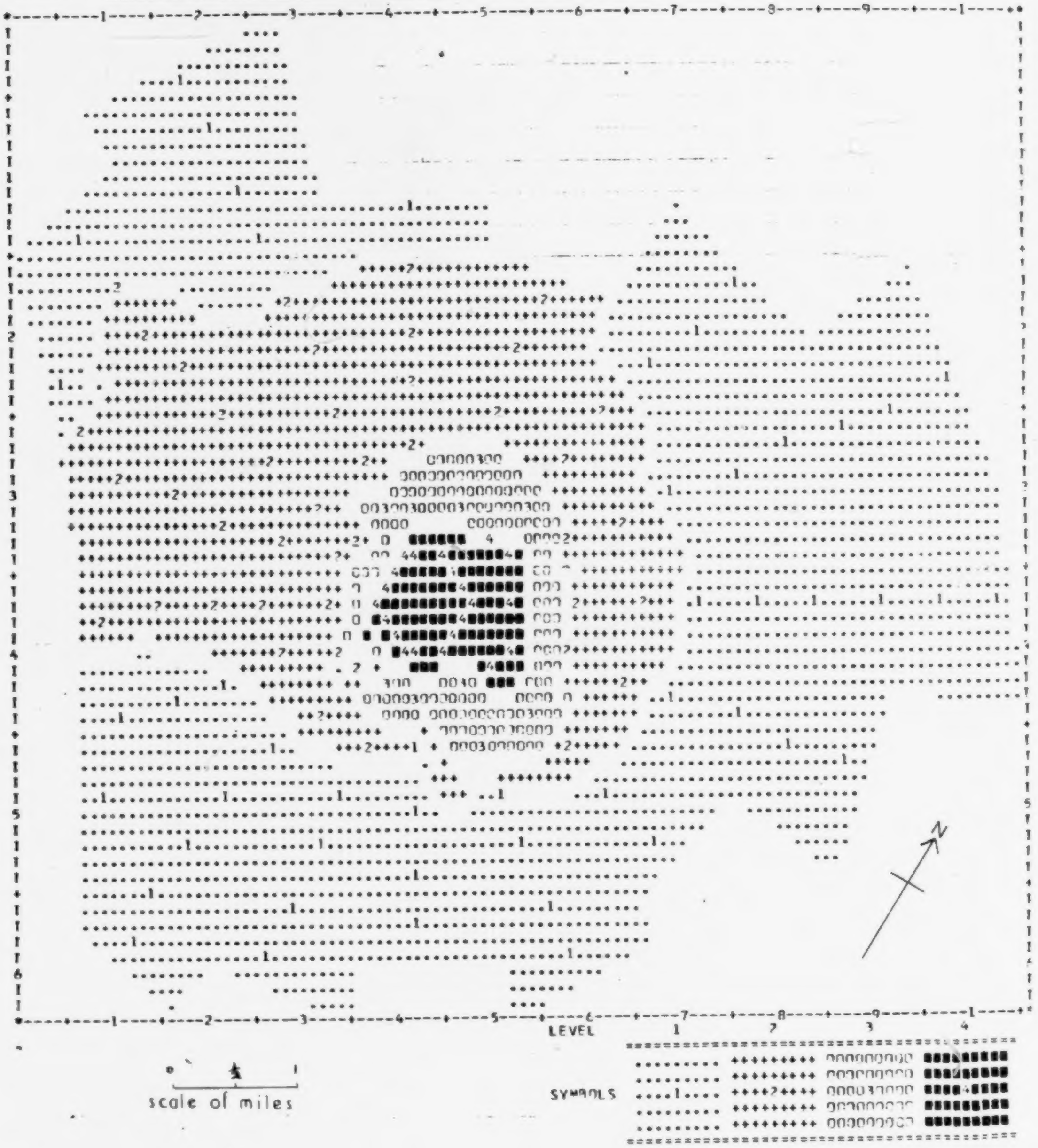

N
LEVEL
1
2
3
4
SYMBOLS
0
½
1
scale of miles

Absolute value range applying to each level ('maximum' included in highest level only).

Level	1	2	3	4
MINIMUM	1.60*	10.78	29.14	60.50
MAXIMUM	10.78	29.14	60.50	78.10*

* Data value extremes.

FIGURE 2. WIVES HOME AREA MAP : SHOWING PERCENTAGE OF HOME AREA AGREEMENT.


N
LEVEL
1
2
3
4
SYMBOLS
scale of miles

Absolute value range applying to each level ('maximum' included in highest level only).

Level	1	2	3	4
MINIMUM	1.60*	10.66	28.78	60.49
MAXIMUM	10.66	28.78	60.49	92.20*

* Data value extremes.

square mile. Although a direct relationship between size of area and the amount of social interaction within it cannot be assumed, it would appear that a significant number of people are oriented toward a small area around the home. Planning policies at the local level should be such that they encourage the individual to involve himself at the local level should he want to, but not to force it upon him.

We have shown that there are geographical divisions within the city that have meaning for the residents, and that they are bounded in some definable and reproducable way. These are a function of the differential utilization of space within the city, and as such are important for planning policies which should attempt to design the structure of the city so that it does not inhibit interaction, but promotes it. Although the results and explanations presented here are only tentative and by no means complete, it is proposed that they suggest some important questions which must be answered in order for worthwhile environmental design to take place.

Notes

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MODELING THROUGH TOY PLAY: A METHODOLOGY FOR ELICITING TOPOGRAPHICAL REPRESENTATIONS IN CHILDREN

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In the past many theoretical models have been offered to explain man's behavior in the environment. It has only been recently that some empirical work has begun to examine actively the relationship between an individual's behavior in and cognition of the environment around him. The basic assumption underlying this paper is that the "internalized mental images of the physical surroundings," hereafter referred to as topographical representations (1), may be an essential component of the interaction between man and his environment. Therefore, the study of the development of topographical representations must be regarded as crucial to an understanding of man's behavior in the environment.

Researchers from various theoretical positions, e.g., Piaget (2), Piaget and Inhelder (3), Piaget, Inhelder and Szeminska (4), Bruner (5), Stea (6), Tolman (7), Hebb (8), Lee (9), Von Senden (10), have inferred from the complexity of an organism's behavior, the existence of some internalized schemata that enables it to represent actions, objects and their spatial relations. As a classic example of this type of inference, Piaget describes an incident with regard to his daughter:

> At 1;4 (3) Jacqueline had a visit from a little boy of 1;6 whom she used to see from time to time who in the course of the afternoon, got into a terrible temper. He screamed as he tried to get out of a playpen and pushed it backward, stamping his feet. Jacqueline stood watching him in amazement, never having witnessed such a scene before. The next day, she herself screamed in her playplen and tried to move it stamping her foot lightly several times in succession. (2, p. 63)

The internalization of the playmate's action is inferred through Jacqueline's ability to reproduce the scene at a later time. Stea (6) in constructing a model for "mental maps" notes:

> It matters not a whit that we cannot directly observe a 'mental map' or even that we cannot know for sure that it is actually there; if a subject behaves as if such a map existed, it is sufficient justification for the model.

These representations serve to facilitate a child's behavior in his surroundings, i.e. the child's ability to construct a topographical representation allows him to find his way around, to explore new territory without getting lost, and consequently influences the way in which the child relates to his surroundings. At the same time the child's experiences and activity contribute to the development of his representation of that environment. Thus, we find a constant interaction between a child's representation of an area and behavior in that environment.

Criteria For Methodological Analysis

The initial problem facing any such investigation of representations of large scale environments is that of how to elicit the topographical representation. This is especially important as we are confronted with a hypothetical construct (topographical representation), whose existence can be inferred only through some behavioral output (methodology). It is likely that the type of methodology used to externalize these representations will have some effect upon the final product, due to differences among the responses of individuals to a particular task and their level of cognitive development. Therefore, it is extremely important to recognize the possible effects that the methodology is likely to have upon the externalized representation.

In developing a technique for studying topographical representations in children, the investigator finds himself confronted with several factors to be considered with regard to the selection and application of a methodology: one set of problems is related to the characteristics of the experimental population; a second group of problems is linked closely with the theoretical base underlying the investigation.

Variables Related to the Experimental Population

In order to maximize the opportunity for the child to respond with an optimal performance, the methodology must be suited to the characteristics and abilities of the experimental sample. One question, therefore, which must be considered in the selection of a particular technique is what skills or abilities does the technique presuppose in terms of the child's mode of response? To examine an internalized schema through a behavioral output, the investigator must be certain that the subject is capable of a wide variety of responses to a specific task. This is a necessary control for the possibility that a given response may be a function of an inability to perform a particular task rather than a consequence of the internal representation. Present indications from completed and ongoing research show that while we may approach an "ideal technique" for some age ranges, differential abilities in such areas as linguistics, motoric and graphic competance variables may cause some methodologies, which place a premium on such skills, to be unsuitable for use with certain populations. However, in looking at these age-related variables, we cannot necessarily select the lowest common denominator of the various modes of response, as some age groups may not be motivated to perform to their optimal capacity if the task is regarded as babyish or uninteresting. This motivational or interest variable may effect the investigator's choice of methodology or merely cause him to modify the instructions given to the child. Still another characteristic of the population which must be considered in selecting a methodology is its cultural and social background variable. The investigator must be certain that the population is well acquainted and proficient with the medium in which he is asking him to respond. Certainly it would be unfair to give a writing implement to a child who has rarely been exposed to crayons, pencils, pens or chalk and expect him to perform on an equal basis with a child who comes from a background which introduced these tools at an early age. Prior experience with the medium is also important as a control against novelty and fear, which could divert the subject's attention from the task to the medium or the experimenter himself.

Variables Related to the Theoretical Framework

It is important to realize that our theories and models of behavior exist primarily for the purpose of (a) organizing given behavioral phenomena into a comprehensible framework, (b) predicting future behavioral phenomena, and (c) explaining the relationships among various components of behavior. To attain any of these objectives, it is necessary that the theory be formulated in a testable way, such that some "critical experiment" can be performed, which can disprove the essence of the theory. Thus, there must exist the possibility of obtaining some evidence which will force the investigator to reject the theory or model. Unfortunately, rather than attempting to develop a better model investigators too often choose to add new constructs to the theory to account for the previously unexplainable phenomena. Such efforts lose the essence of the original theory, making it too cumbersome for practical use.

In almost any field we find investigators who have collected multitudes of data and yet are unable to organize their data into a coherent theory or conceptual framework. At the other extreme we find the theoretician who assumes a basic framework before dealing with the existing data or information. While the "obvious solution" lies on that happy medium point on the "theory without data-data without theory" continuum, such is easier said than done. Both the inductive and logical deductive approaches to the generation of theory necessitates that the researcher make certain assumptions with regard to the significant determinants of behavior. With an inductive approach the investigator must decide upon the relevant factors and dimensions of the data which are to be considered in the model. A deductive approach arbitrarily determines the relevant factors in behavior which are to be studied. Often the investigator overlooks dimensions of the behavior which may be significant.

It is neither my purpose nor interest to propose a resolution to this age-old debate between these two approaches to generating theory. Rather, I would like to suggest that researchers take a closer look at their empirical approach and begin to recognize their underlying assumptions. Too often investigators fail to acknowledge their biases and end up drawing conclusions with regard to questions which their studies are unable to handle. This is particularly true of theories whose assumptions allow them to ignore issues which other theories may deal with extensively.

To summarize this brief discussion of the influence of an investigator's theoretical bias upon his choice of methodology three points should be noted: the researcher's theoretical biases or assumptions tend to restrict the scope of a behavior considered in an investigation; the researcher should constantly test those assumptions with a "critical experiment" whose failure will force him to reject his model as a viable theory; the researcher should be aware of the limitations of any methodology so as not to make unwarranted inferences about issues which the experimental design is unable to handle.

Techniques For Eliciting Topographical Representations

For organizational purposes it is possible to dichotamize the techniques for eliciting topographical representations that have been used in past research, on the basis of the type of behavioral output obtained from the subject (11) (See Chart 1.)

The first type distinguished may be labeled external representations of the large scale physical environment. Methodologies contained in this category entail the construction of the

TECHNIQUES FOR ELICITING TOPOGRAPHICAL REPRESENTATIONS

	TECHNIQUE	OUTLINE OF PROCEDURE	COMPETENCE VARIABLE	ILLUSTRATIONS OF THE TECHNIQUE
EXTERNAL REPRESENTATIONS	Pictorial Sketches & Drawings	Subject is asked to "draw a picture" of an environment as seen from a horizontal or oblique perspective.	graphic motoric	Anderson & Tindal (24), Arnheim (25), Hart (22), Ladd (26), Lee (9), Piaget & Inhelder (3)
	Maps Constructed by the Subject	Subject is asked to show the location of objects in the environment, (a) at a reduced scale, (b) from a vertical point of view, (c) using designated symbols to represent landscape elements.	graphic motoric	Appleyard (27), Gittins (28) Hart (22), Laurendeau & Pinard (15), Lynch (29), Piaget & Inhelder (3), Piaget et al. (4), Rand (30), Shemyakin (31), Wood (32)
	Modeling Environments Using Toys	Subject is asked to place toy block replicas of elements in the environment in positions corresponding to their placement in the environment,	motoric	Laurendeau & Pinard (15), Piaget & Inhelder (3), Piaget et al. (4), Stea, Blaut et al. (21)
	Verbal Descriptions & Reports	Subject's verbal comments and descriptions of an environment are analyzed. Analysis of literature and other popular culture for the images conveyed. Use of scaling devices and environmental inventories.	linguistic	Anderson & Tindal (24), Gittins (28), Lynch (29), Piaget & Inhelder (3), Piaget et al. (4), Von Senden (10), Boulding (33), Strauss (34)

Figure 1a.

spatial arrangements of landscape elements. Such response mechanisms include (a) pictorial sketches and drawings, i.e., graphic drawings of the environment from horizontal, vertical and oblique perspectives, (b) maps constructed by the subjects, i.e., representations of the environment at a reduced scale as seen from a particular perspective, using symbols to stand for landscape elements, (c) modeling with toy landscape elements, i.e., the construction of a representation of an environment with the use of toy (blocks) landscape elements, and (d) verbal descriptions and reports of experiences in a given environment. A second type of output, which has its origins in the rat-maze experiments of E. C. Tolman (7), involves inferences drawn from observable behavior of the subject. Methodologies in this category include (a) the work with animals in a controlled laboratory setting, (2) observations and inferences from overt behavior, which involve unobtrusive observations of childrens' play behavior, (c) inferences drawn from specific way-finding tasks and (d) inferences drawn from animal behavior in their natural habitat.

To explicate and illustrate some of the methodological criteria suggested in the previous section and the application of particular techniques to the problem of eliciting topographical representations, an analysis of one type of methodology modeling through toy play, as applied by Mark, Silverman and Stahlbush (12), will be undertaken. Particular emphasis will center around the techniques used to supplement the modeling procedure and the problems which the methodology as a whole is able to confront.

Modeling Through Toy Play As a Means of Eliciting Topographical Representations

	TECHNIQUE	OUTLINE OF PROCEDURE	COMPETENCE VARIABLE	ILLUSTRATIONS OF THE TECHNIQUE
INFERENCES FROM BEHAVIOR	Experimentation with Animals	Animals (rats) are studied as they move through mazes. Their choices of pathways to the goal are noted for the effects of learning or "past experience" from previous trials.		Tolman (7)
	Inferences from Animal Behavior in their Natural Habitat	Animal behavior is observed in a natural setting (e.g. in a jungle). Inferences are drawn about the internal processes responsible for particular behaviors.		Altman & Altman (35)
	Observations & Inferences from the Behavior of the Subject	Experimenter observes the behavior of people in the environment. He then draws inferences about the processes underlying that behavior. These inferences are sometimes tested with a more controlled experimental design.	motoric linguistic	Freeman (36), Werner (37), Piaget, Brown (38), Mandler (39), Von Senden (10), cf. Shemyakin (31) who reviews some of the major Russian research.
		This technique is often used in observations of children's play behavior in a naturalistic setting. Inferences are drawn about the underlying processes through analysis of the child's actions and verbal outputs.	linguistic	Piaget (1,40), Piaget & Inhelder (3), Piaget et al. (4).
	Way-Finding Tasks	The subject's movements in response to specific directions are observed.		
		Subject is asked directions or locations of landscape elements.	linguistic	Follini (23), Lynch (29), Ryan & Ryan (40)

Figure 1b.

Mark, Silverman and Stahlbush (12) conducted a pilot study for the purpose of (a) developing a methodology for eliciting topographical representations from children of elementary school age, and (b) generating hypotheses for formal investigation concerning changes in topographical representations that may be a function of developmental level. The sample included 31 children between the ages of six and twelve, from Weston, Massachusetts, an upper-middle class suburban community near Boston. These children, after having been categorized by their developmental level according to their performance on Piagetian-type tasks, were asked to build a model of "their school and the area around their school" using toy blocks (houses, cars, trees, schools, churches, etc.) to represent elements in their environment. To understand better the reasons for their decision to apply a modeling technique to the problem under investigation, a brief summary of Piaget's theory of intellectual development and the construction of the fundamental concepts of space from which the study was designed is necessary (13).

Piaget's Theory of the Development of Spatial Cognition

For Piaget the problem of intellectual development is one of an invariant structural sequence, i.e., the organism passes through a progression of stages, each qualitatively different from its predecessor and involving a hierarchic integration of structures formed at a previous stage. The mechanism of adaptation or change hypothesized by Piaget is one involving the assimilation of data from the external world (experience) into already existing and structured schemata and the accomodation or readjustment of the schemata to the new data. Change or development is the result of the progressive coordination or equilibration between the processes or assimilation and accomodation. Thus, the development of intelligence is seen as the result of a complex interaction between the organism and its environment (18, 19).

After much experimentation Piaget and his coworkers identified four major periods in the development of the fundamental concepts of space. During the initial stage, the sensorimotor period (birth to about two years), children begin to construct a system of relationships between objects and their actions upon them, thus coming to understand themselves and the objects around them as permanent entities in the environment. However, these achievements are made only on the level of action, rather than on a symbolic or representational plane.

The child slowly begins to internalize the actions that were constructed during the sensorimotor period. He becomes able to act upon objects that are symbolized or internally represented. During this preoperational period (roughly two to seven years) the child is able to perform elementary transformations upon these internalized actions. However, the child is still unable to coordinate them into a reversible system. The onset of the third stage, the concrete operational period (roughly seven to eleven years), is marked by the increased coordination of these transformations into what Piaget refers to as "operations" or a system of reversible internalized actions, i.e., what can take place in one direction may also occur in the opposite direction. Piaget (16, p.48) looks at an operation as an action whose origins lie in the sensorimotor schemata. Before becoming operational the actions constitute the nature of sensorimotor intelligence. Throughout the preoperational period, actions are slowly internalized, enabling the child to act upon symbols. However, these operations possess only faint signs of reversibility and do not become truly "operational" until the level of concrete operations. The major limitation imposed on the child by concrete operations is that the operations may only be applied to real objects. It is not until the level of formal operations (roughly 11 years and older) that the child is able to transpose these operations to the plane of abstract thought. The adolescent is capable of dealing with abstract hypotheses or propositions. Thus, "formal operations provides thinking with an entirely new ability that detaches and liberates thinking from concrete reality and permits it to build its own reflections and theories." (16, p.63)

The effect of concrete and formal operations upon the development of the fundamental concepts of space can be seen in the construction of specific spatial relations. An analysis of space led Piaget to three separate types of spatial relations: topological properties, the qualitative relationships such as proximity, separation, sequence and closure, which remain invariant under continuous deformation excluding tears and overlaps; projective properties, the relations constructed in terms of a particular point of view, which remain constant during transformations of perspective; euclidian properties, those relationships of a metrical quality that coordinate space with respect to a system of outside reference points. Piaget and Inhelder (3, pp. 17-79) and Laurendeau and Pinard (15, pp. 28-110) performed a series of experiments dealing with the recognition of the shapes of objects by "haptic perception." Both sets of findings noted that although the child could form internal representations toward the end of the sensorimotor period, he could not construct or differentiate (in representation) the topological properties of objects until midway through the preoperational period. They also showed that from the topological relations derive the ability to represent the projective and euclidian shapes of objects. However, the general coordination of the projective and euclidian relationships develop along with the formation of concrete operations. The final equilibrium of these spatial relations is reached only with the development of a stable reference system, at the level of formal operations.

Experimental Methodology

The fundamental assumption underlying the work of Mark et al. (12) was that the formation of topographical representations involves an application of these fundamental concepts of space to the problem of representing environments which are too large to be perceived at once. We can view this process as involving the construction of representations of areas which can be perceived from specific locations and the amalgamation of these individual images to form a topographical representation.

In an effort to examine the process of how the child organizes the individual images, the investigators needed a technique that would produce a representation in a form capable of being analyzed in terms of the spatial relations between elements. By looking at the child's ability to construct topological, projective and euclidian relations between objects of an area that he is unable to perceive at once, we may see some relationship between that ability and the child's developmental (operational) level. In particular we were interested in the effect of concrete operations upon the topographical representations of children, i.e., changes in the child's ability to construct a representation of a macro-scale environment that are a function of the attainment of a higher developmental level.

The need for such a representation suggested a methodology involving the construction of a map of some type of large scale environment. The map itself could be either graphic (drawing) or a model built with miniature replicas of landscape elements. As our specific interest in the effect of concrete operations would require us to work with children from the late preoperational stage (approximately six years) to the level where the children had clearly attained concrete operations (about eleven to twelve), we decided upon a nongraphic technique as there appears to be a significant difference in motoric and graphic ability between the ages of six and twelve years (20). Therefore, we selected a modeling procedure to elicit topographical representations.

The Task of Modeling

Essentially, modeling is a task which asks the child to "tell us what he knows" about the spatial arrangement of features of the environment through his placement of toy block replicas of landscape elements. The externalization of the representation is accomplished through what the author believes to be a process of the child's limitation of his conception or representation of the environment, i.e., we are attempting to look at the structure and content of the child's internalized schemata through his ability to adapt them to the demands of our modeling procedure. The use of the modeling task to elicit topographical representations requires the child to play with the toys in such a way as to mold his placement of them to his representation of reality. Thus, one hopes that during the modeling procedure, the internal representation will influence the manner in which the child uses and places the toys.

However, it is possible that some of the younger children will not use the toys to imitate reality, but rather in a manner where they play to satisfy their own emotional needs and desires. In other words, we must be wary of the child who fails to adapt the qualities of the toys to objects in the environment. As an example of this phenomenon from my own experience, very young children often enjoy lining up toy houses and then driving a car over the roofs. Here the child does not meet the demands of reality ("cars do not normally go on houses"), but may play in such a way as to act out his own fantasies and desires.

When working with children at the preoperational level, it is especially important to recognize the differences between these two types of activity. Children who use the toys to meet their own needs may reveal what would seem to be an inferior knowledge of the environment, whereas the real explanation could well be related to their response to the toys.

Several procedures have been suggested by previous work to encourage a use of the toys that would best externalize the child's representation of the area (21). If we choose to use a structured methodology, i.e., giving the child specific instructions concerning the use of the toys (e.g., "Show me your house and all the things around your house."), we may want to allow the child a period beforehand to play with them in an undirected situation. This would afford him the chance to act out his fantasies and become accustomed to the toys before being asked to perform a specific task. A second solution, geared primarily to use with younger children, has been suggested in one of the toy play methodologies used by Stea, Blaut et al. (21). In order to elicit representations of a landscape too large to be perceived at once, the experimenter simply asked the child to "play with the toys" on a piece of paper. The child's final placement of the toys was then marked and analyzed according to a set of criteria for determining their relation to typical landscapes. Paiget's use of his "clinical method" suggests another procedure to externalize the child's representation. By carefully observing and recording the spontaneous actions, comments and final output as the child plays with the toys, as well as posing questions to the child, the experimenter may be able to infer much about the nature of the child's representation of the environment.

To further insure comparability between subjects as they relate to the toys, an identification procedure, asking the child to name the toys, was devised. The technique finally arrived upon by Mark et al. (12) was patterned after a similar procedure used by Stea, Blaut et al. (21). Each type of toy landscape element (house, big house, car, truck, tree, church) was removed individually from a bag and shown to the child who was then asked, "What is this?" For any identification which did not correspond to our intentions, we asked the child if the object reminded him of anything else.

The importance of the identification procedure was highlighted in the pilot work of Mark et al. in which the identification procedure was dropped in the case of three of thirty-one subjects. Each of the three children failed to use the blocks as landscape elements in their models of "their school and the area around their school." Rather, they chose to use the individual toys as part of landscape elements represented in their models. (One boy used a total of twenty-two individual blocks to construct his school building!) While we must be cautious in making any generalizations concerning the effect of an identification procedure because of the small number of cases in which the above phenomenon was observed, it still remains an interesting observation.

After the identification procedure the investigators are faced with the problem of how to direct the child's activity and specifically what to tell the subject. This phase of the modeling procedure involves a linguistic input which, for the youngest children, one hoped to minimize. In view of some preliminary findings of Stea, Blaut et al. (21) with regard to linguistic inputs and the verbal outputs in three, four and five year old children, one might tend to favor a purely unstructured play setting for the younger preoperational children, asking them only to "play with the toys."

For children above the age of five who are first becoming accustomed to directed activities, it might be possible to confront them with a more directed task. There still exist a number of possible types of instructions. The first would involve asking the child to construct a model of some general landscape gestalt (e.g., "a town,""a city," "Worcester," "the world," etc.) The major disadvantage to these directions revolves around the child's inability to comprehend the meaning attached to such words. (The work of Hart (22) suggests that it is not until the age of eight or nine that the child acquires ar accurate understanding of such words.) Therefore, another procedure was developed by Mark et al. (12) in their pilot study with elementary school children. Working on the assumption that, in general, children should best be able to represent those areas which have a particular significance for them in their everyday routines, Mark et al. (12) asked children who were attending two schools in close proximity, to build a model of "your school and the area around your school." This afforded us the opportunity to draw comparisons among represenations of a common area possessed by children at various developmental levels.

Mark et al. (12) posed the modeling problem to the child in a task-oriented situation. The experimenter asked the child to construct his model for some children who would be visiting the school, so as to enable them to find their way around the school grounds. There were several reasons for approaching the modeling procedure with the task orientation. In general, the children seemed to be more comfortable in a testing situation in which they would be performing as experts for the benefit of other children. This helped to overcome some of the initial fear involved in making a model. It also tried to induce them to include on their maps features which they, as children, thought to be important, rather than what might interest the testers. Furthermore, the task-oriented directions allowed the investigators an opportunity to supplement the modeling output with descriptions of the final product. After the child announced that he had finished constructing the model, the experimenter asked the child to explain the content of his map in the guise of a "tour" of the area, pointing to specific landscape elements as he described their functions. If the child forgot to identify any objects on the map, the experimenter would then question the child about them. In an effort to have the child acknowledge any distortions of which he may be aware in the spatial arrangements of objects on the map, the investigator asked the child if he would make any changes in the map were he given the chance to do it again. This marked the end of the modeling procedure.

Limitations Upon the Modeling Procedure

There are several limitations upon the modeling technique, related to its ability to control for experience. As applied by Mark et al., modeling was only able to deal with the child's general past experience in an area. While one can attempt to control for the experience variable by using children who had been (a) attending their school for a particular length of time, or (b) living in the same town since birth, such gross measures of control over experience may not be a true indicator of the children's experience in the area. Children explore different areas, play in different places (e.g., boys play on the baseball and soccer fields while girls play on swings and slides) for varying lengths of time. A more effective control of the child's experience in an area may be to study the formation of representations of a previously unexplored area, thereby affording the investigator the opportunity to note the specific areas that the child has actively experienced.

However, it may be difficult to use a modeling technique to look at the construction of representations of a previously unexplored area. First, a modeling task may only be performed in a quiet, uncongested room, away from the area being explored. Therefore, we could only look at the child's representation periodically, in a static state, losing the opportunity to observe the actual processes involved in their formation. Second, modeling, though revealing about the spatial relationships that the child can construct among elements, shows little about the dynamic nature of the representation, i.e., what it means to the child in terms of his behavior and ability to find his way around the environment. It has been suggested from both Piaget's work and the study of the construction of a behavioral space by Follini (23) that some type of behavioral output, particularly the child's movements in the environment, may be more useful in this regard. Third, as was mentioned above, modeling can only deal with experience in a global manner. It cannot look at the processes occuring during the period of exploration.

While the modeling procedure alone may be inadequate to deal fully with some of these questions, we have found it able to serve as a basic technique which may be supplemented by other methodologies, including behavioral outputs, verbal descriptions and possibly graphic tasks with older children.

All of the children tested with our modeling procedure seemed to respond well in terms of relating to the toy blocks and their comprehension of and interest in the task. Piaget et al. however, did suggest a minimum age with which such a modeling technique could be used:

> Children cannot be questioned below the age of four or five, which is when in Switzerland, they first enter the Kindergarten... Even between four and seven, children cannot be made to stay the length of the experiment, unless they became interested in the questions asked. (4, p.5)

Thus, we should be cautious in adapting the structured modeling procedure to children below the age of four. Perhaps when working with those younger than four, we should rely more heavily, as do Piaget and his collaborators, upon the spontaneous remarks and activity of the children during walks through the environment, i.e., their activity in the environment.

Summary

This paper has attempted to discuss some basic methodological issues in studying the development of topographical representations. It has shown how the overall selection and application of a methodology should be governed largely by the questions under investigation which are related closely to the theoretical framework underlying the research. The problem of modifying a methodology to minimize the competance motivational and sociocultural variables was also elaborated upon. These points were illustrated with reference to a pilot study based upon the developmental framework of Jean Piaget. The actual procedure finally adopted, as well as the reasons for modification and the addition of several techniques were explicated as they related to the variables under discussion.

Notes

(1) Shemaykin (31, p. 193) formally introduced the term "topographical representation" to refer to "a mental plan of some area which is a reflection in man's mind of the spatial placement of local objects in relation to each other and himself."

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(11) The dichotamy presented here was initially suggested by Gary T. Moore in a research workshop at Clark University during the spring of 1971.

(12) Mark, Leonard & Silverman, Stuart & Stahlbush, Robert The effect of cognitive development upon the cognitive representations of the large scale environment. Unpublished paper, Clark University, 1971.

(13) For a more detailed summary of the development of the fundamental concepts of space, cf. Hart and Moore (14) and Laurendeau and Pinard (15, pp. 8-17). A complete account of the findings of Piaget et al. on spatial cognition may be found in the following references: Piaget and Inhelder (3), Paiget, Inhelder and Szeminska (4, pp. 3-26). Also cf. Piaget (16) and Piaget and Inhelder (17) for excellent summaries of their overall developmental theory.

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MAPPING THE CITY: ENVIRONMENTAL COGNITION OF URBAN RESIDENTS

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Introduction

Most past research concerned with the environmental cognition of urban residents has dealt with generalized urban imagery. This research has occasionally attended to mapping the divergent views of diverse segments of the population recognizing, at least implicitly, that the relevance and salience of elements in the environment may be as much a function of the concerns and involvements of the observer, as they are attributable to aspects which inhere in the environment itself (Ladd, 1970) (Lee, 1968) (Los Angeles City Planning Commission, 1971). It is as though the variable life spaces of individuals, or their orbits, as Strauss refers to them (1961) circumscribe their impressions of the urban landscape. Thus, whereas the early work of Lynch (1960) stressed the notion of imageability, and thus focused on the environment in its own right (e.g., aspects of physical structure are conducive to sharp delineation), more recent work has begun to attend to the differential significance or environmental elements for distinctive categories of observers.

The concern of the research reported here is twofold. First, an attempt is made to assess urban residents' cognition of their immediate environs. More particularly we are interested in the extent to which differential involvement in a residential area influences how it is "seen." Although there are notable exceptions, much of the research on cognitive mapping has dealt with imagery of the cityscape while ignoring respondent awareness of the immediate vicinity. Second, an attempt is made to determine whether there are consistent and significant differences in how men and women (more specifically, husbands and wives), because of differences in their daily activities, view and graphically represent their residential environment.

In fact there is probably some convergence between these two concerns. For the purpose of this study we chose to consider a population which closely approximates what Janowitz (1952) has termed a "community of limited liability," a population of cosmopolitans (Webber, 1967) with the resources and incentives to be substantially involved in the larger community and, to the extent that this is accomplished, to exhibit a limited commitment to the residential area.

Sex-Role Differences and Environmental Cognition

Our assumption is that the division of labor in the household--still largely defined by sex roles--is sufficient to create distinct (if partially overlapping) rounds of activity for husbands and wives, with wives being more "tied down" to the residential environs. This difference is probably exaggerated when young children are present in the home inasmuch as their needs determine a relatively circumscribed round of daily activity centered on the home and school. Moreover, children often provide the catalyst for parental contact thereby serving as a vehicle for creating and maintaining a local network of acquaintance and pattern of communication. We would expect this "exaggerated" difference to hold in even the most cosmopolitan (least residentially committed) population, though obviously the degree of difference in orientation to the home area will vary from population to population.

Unfortunately our sample is too small to allow detailed analysis of this phenomenon. Nevertheless, without controlling for the presence of children, we would expect to find differences in environmental cognition among male and female respondents. In effect what we have done, by focusing on a reasonably cosmopolitan population --one of limited liability--and by not controlling for the presence of children in the home, is to minimize the likelihood that we will find significant differences between the men and women in our sample.

We already know from other analyses of the same data that female, as compared with male, respondents in our sample tend to conceive of a somewhat more extensive territory as their home area (Everitt and Cadwallader, 1972) and that a substantially higher proportion of their total weekly driving is limited to that area (Everitt and Orleans, 1971).

As Everitt and Cadwallader indicate,

> "The areas designated by wives were larger than those of husbands, with medians of 1.3 square miles and 0.7 square miles respectively. (In addition) 28 percent of the wives, as against 20 percent of the husbands, drew at least one of (the area) boundaries off the map. (Moreover) in 56

> percent of the sample the wives' maps were larger than their respective husbands' maps as against 41 percent of the cases where the reverse was true."

Husbands reported driving an average of 201.06 miles per week of which 49.22 or 24 percent were driven in the home area. Wives, by comparison, reported driving 82.36 miles per week on the average of which 35.94 or 44 percent were driven in the home area.

These data appear to support our contention that husbands' and wives' experience and conception of their residential environs differ. In relative terms, wives as compared with husbands, drive proportionately more of their total mileage in the "neighborhood," 44 percent as compared with 24 percent. Moreover, differences in husbands' and wives' conception of the extent of their "neighborhood" appear to be related to a difference in the amount of time each spend in the area on the average (taking mileage driven as a proxy measure for time). But how, if at all, do they differ in the way in which they structure and portray their residential environment? How comprehensive is their image of it? How detailed? How much variability is there in the environmental cognition of husbands and wives in this population?

Insofar as husbands and wives differ in their daily experience of the residential area we expect their mapped impressions of it also to be distinctive. In particular we expect the cognitive impressions of men to be both more comprehensive and more superficial than that of their wives. Our assumption is that whereas wives tend to be occupied with the daily tasks of child rearing and homemaking which involve them directly and repetitively with local ammenities, husbands, given the functional and physical separation of residence and work, tend to be at best indirectly and sporadically involved with those same ammenities. Accordingly, the men should have a general knowledge of the physical layout of the area surrounding their homes, but lack (be less concerned with) detailed information about the ammenities therein.

Operationally, we expected husbands in our sample to have a more extensive knowledge than their wives of the layout of streets in the area. A comprehensive map in our terms would include both peripheral and internal street systems. We considered a detailed knowledge of the area to be evidenced by an ability to spontaneously enumerate and locate local ammenities--to establish the presence of landmarks. Thus a detailed map in our terms is a comprehensive map which includes reference to an above average number of local landmarks and minor streets.

Description of Sample and Method

Our respondents were chosen, using a systematic random sample, from one census tract in the Mar Vista area of Los Angeles; a predominantly middle class residential area to the east of Santa Monica. The census tract itself is almost completely residential, although there are shops at three corners. Single family residences comprise 80 percent of the dwellings, the balance being apartments. Mar Vista is located quite centrally within western Los Angeles, enjoying easy access to both the San Diego and Santa Monica freeways as well as to a large variety of urban subcenters such as Beverly Hills, Santa Monica and Venice.

The average income of the sample was between $15,000 and $18,999 with only 15.3 percent giving their income as below $11,000; the average educational level was 'some college' with only 3.1 percent of the husbands and 7.7 percent of the wives not having at least completed high school. Residential stability and some integration into the area (through children) were also factors involved in selection of the population studied. In this sample, 86.2 percent of the husbands had lived in the area for more than three years, and 81.6 percent of the wives had done so. Of the respondents, 54 percent had children (under 18 years old) living at home, and a further 21.5 percent had previously had children living at home while living in the area.

Married couples were interviewed, with each husband and each wife completing a separate questionnaire. The original sample was 164, out of which 114 'qualified' as married couples; out of these, 65 couple-interviews were obtained yielding 55 usable maps from the husbands and 53 from the wives.

In the course of the interview each respondent was given a base map of the area surrounding their homes. A facsimile of the base map, an 8" x 11" sheet of paper with some intersections already drawn on it, appears herein as Figure 1. Additional information recorded here, though not on the respondents base map is the census tract sampled (shaded area) and major thoroughfares included in the respondents reference systems (dotted lines). After being given this map the respondent was asked to complete the following tasks:

> Please mark on the outline map the area you regard as your home area.
>
> Within this area, please indicate those features you consider to be distinctive, interesting and important (such as streets, buildings, hills, etc.). We are interested in the physical pictures of things. It is not important if you can't remember the names of the streets and places.

> Please indicate the boundaries of the area and the location of your home. Please indicate the direction of North on the map.
>
> Using the RED PENCIL, please mark the landmarks listed on CARD 1.
>
> Using the BLUE PENCIL, please mark any other landmarks in this area.

Results: Comprehensiveness of Imagery
Analysis of the street configurations provided by our respondents' maps suggest that husbands and wives differ in the manner in which they represent the local area in map form. Of the 55 maps drawn by husbands, 45 made use of the coordinates provided on the base map or were organized around major thoroughfares drawn in by the respondent. The comparable figure for the wives was 37.

TABLE 1

Street Reference Systems Employed by Husbands and Wives in Drawing Local Area Maps

	own reference system employed (base map coordinates largely disregarded)	base map coordinates supplemented with respondents reference system	total
husbands	18	25	43
wives	24	12	36
total	42	37	79*

$\chi^2 = 3.89 \qquad p < 0.05$

*Three maps of respondents who relied exclusively on base map coordinates and 26 in which there was no evidence of a coordinate system having been used have been excluded from this table.

As Table 1 indicates better than half or the husbands (56 percent), as compared with one-third of the wives, made use of and added to the coordinate system supplied on the base map. By contrast, approximately two-thirds (65 percent) of the wives, as compared with less than half of the husbands (40 percent), made little or no reference to the available coordinate system, preferring instead to draw in two or more of the major streets (indicated on Figure 1) for reference purposes. It appears as though the wives start by locating their homes as a basic reference point, and proceed by working out toward the periphery of the area, whereas the husbands (perhaps having a more abstract imagery) start with the given points of reference and work back to the home.

Insofar as the wives tend more often to rely on their own reference system, one which is internal to the area, and husbands tend instead to make use of the peripheral coordinates supplied on the base map as well, the maps we obtained support our expectation that husbands would have a more comprehensive image of the area surrounding their homes than their wives.

Results: Detail of Imagery
Looking now only at those maps containing maximum information (22 of the husbands' maps and 24 of the wives' maps) we can assess differences in the detail of the maps. What we find is that regardless of which reference system is employed, wives are more likely than husbands to indicate the presence of point details (see note 'd' to Table 2 for the definition of point details). 82 percent of the wives' maps as compared with 58 percent of the husbands' maps contain references to at least four "landmarks" othan than those the respondent was specifically asked to locate. Less than one-fifth (18 percent) of the wives' maps, as compared with 42 percent of the husbands' maps, supplied information about minor streets without also locating at least four point details.

As indicated in Table 2, 46 percent of the husbands and 45 percent of the wives drawing reasonably complete maps made use of two reference systems while locating point details with or without indicating the location of minor streets. The principal difference between husbands and wives is apparent when one examines the maps employing only the respondents own reference system. Eight such maps of wives, or 37 percent of the total, as compared with three of the husbands' maps, or 12 percent of the total, contain information about point details.

None of the differences reported here are likely to be statistically significant. Indeed it would not be appropriate to apply any test of significance to these data given the erosion of the base N due to the necessary elimination of a large number of maps because of incomplete data (see note 'a' to Table 2). However, the differences recorded are in the direction hypothesized. Accordingly, further research to test the hypothesis appears to be indicated.

TABLE 2

Cross Tabulation of Refence Systems and Information Displayed in Local Area Maps Drawn by Husbands and Wives (N = 46)[a]

	REFERENCE SYSTEM					
	own reference system [b]		base map coordinates with own reference system [c]		total	
WIVES						
point detail with or without minor streets	8	37%	10	45%	18	82%
minor streets without point detail	4	18%	0	---	4	18%
total	12	55%	10	45%	22	100%
HUSBANDS						
point detail with or without minor streets	3	12%	11	46%	14	58%
minor streets without point detail	4	17%	6	25%	10	42%
total	7	29%	17	71%	24	100%

[a] 31 of the 53 usable maps obtained from female respondents and 31 of the 55 usable maps obtained from male respondents lacked minimal criterion data for either reference systems or information displayed and could not be used in this cross-tabulation; the resulting total N for this table is 46 (22 for female and 24 for male respondents).

[b] Respondent used as reference points two or more major streets in the area (i.e., Barrington, McLaughlin, National, Palms, Inglewood) but did not use boundary coordinates given on the base map supplied in the interview.

[c] Respondent used one or more of the boundary coordinates supplied on the base map, in addition to using at least two of the major orienting streets in the area (listed in 'b' above).

[d] Point detail refers to significant referents in the sense of distinctive buildings, or other landmarks and natural ammenities and physical features; minor streets refers to streets other than the boundary coordinates provided on the base map or major thoroughfares generally added as reference lines. To qualify for inclusion in this analysis at least four point details and/or two minor streets had to be indicated on the respondents' map.

Sex Differences in Mapping Ability

Just as a hungry person can only selectively attend to restaurant signs if he is familiar with the language in which all signs are written, so too can we assess differences in the cognition of our respondents only if we can assume rough equivalence in their ability to draw maps. Can we eliminate as a plausible competing explanation for our findings systematic differences in the ability of men and women to represent the environment in map form?

Almost equal numbers of male and female respondents in our sample were either unwilling or unable to draw usable maps (10 men and 12 women). Considering all of the usable maps we obtained (55 for the men and 53 for the women) we find, as indicated in Table 3, substantial equivalence in the numbers of point details and minor streets noted on all of the maps drawn by our respondents.

TABLE 3

Frequency Distribution of Point Details and Minor Streets Displayed on Local Area Maps of Husbands and Wives

Frequency	Point Details		Minor Streets	
	Husbands	Wives	Husbands	Wives
0	6	9	20	23
1	14	7	16	17
2	10	9	6	4
3	10	6	6	5
4	3	9	3	3
5	3	3	1	0
6	4	2	3	1
7	1	4		
8	0	2		
9	2	0		
10+	2	2		
base N	55	53	55	53

Whereas the differences in the maps of husbands and wives discussed above refer to configurations of information (the interrelation of reference systems and details) the information base (the amount as opposed to the type of information) is similar for both male and female respondents. We take this as suggestive evidence for negligible differences in the mapping ability of the husbands and wives in this sample.

Refinement of the Method

The administration of a questionnaire of the type employed in this study is almost invariably a tedious and time consuming process. It is difficult at best to obtain usable maps from respondents (even well educated respondents) many of whom have rarely if ever attempted to express themselves and summarize their impressions of the environment by drawing a map. Moreover, any attempt to systematically relate cognitive imagery to behavior ultimately depends upon the successful solicitation of reasonably concise and detailed information about the respondents' backgrounds and patterns of activity. How can the instrument employed in this research be modified and improved in subsequent studies?

In previous work we simply asked our respondents a standard mapping question and supplied a blank sheet of paper on which they could draw a map. Because we wanted to elicit a tabula rasa image we offered no cues to guide the respondent in the map making task (Orleans, 1972). The base map supplied the respondent in this study (see Figure 1) was intended to give an initial reference base while establishing only the minimal constraint imposed by the provision of an implicit scale. In addition to the base map itself, we supplied a list of "landmarks" to stimulate the respondent to include as much detail as possible and to allow for the evaluation of relational accuracy (through an assessment of the placement of details relative to one another).

On the basis of the data obtained we are now inclined to extend this methodology in two ways. First, we can give matched samples of male (and alternatively female) respondents base maps with either only the street structure within the census tract drawn in or with only a peripheral reference system of the type employed here, we can further explore the phenomenon of comprehensiveness of imagery discussed above. Second, we can provide our respondents with a detailed street map of the entire area (Figure 3) and several typologically organized open-ended lists of "landmarks" to be administered in series and recorded with a color code on the map by having the respondent use colored pencils and add additional unsolicited information at any time. In this manner we can more systematically explore both selective attention to environmental detail as well as how the respondents' imagery is structured (i.e., what items known to the respondent are "seen" in the context of what other items?)

Conclusion

The research reported here has only begun to scratch the surface of a complex and too little studied phenomenon--the imagery urban residents have of their residential environs. It does suggest, however, that aspects of that imagery

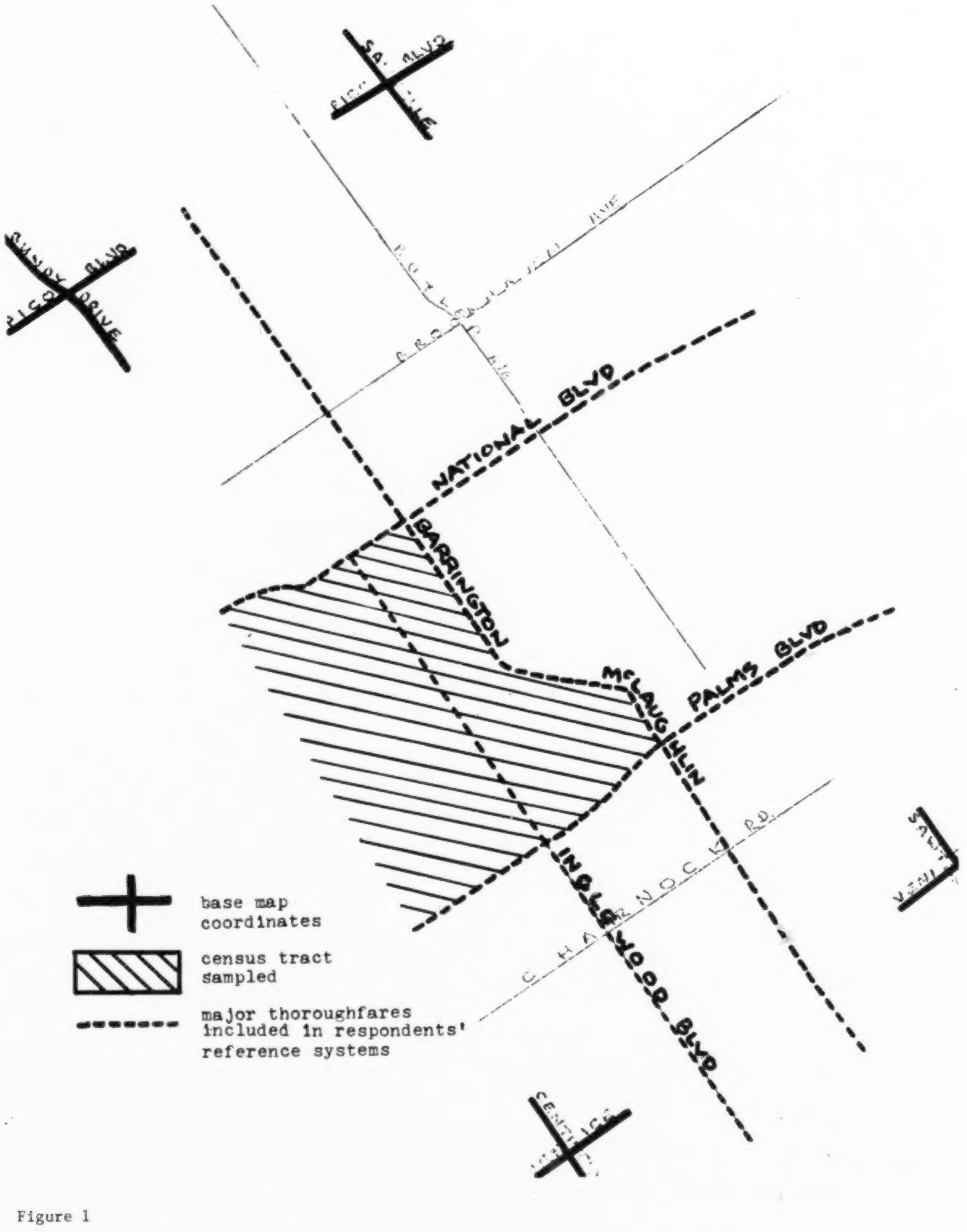
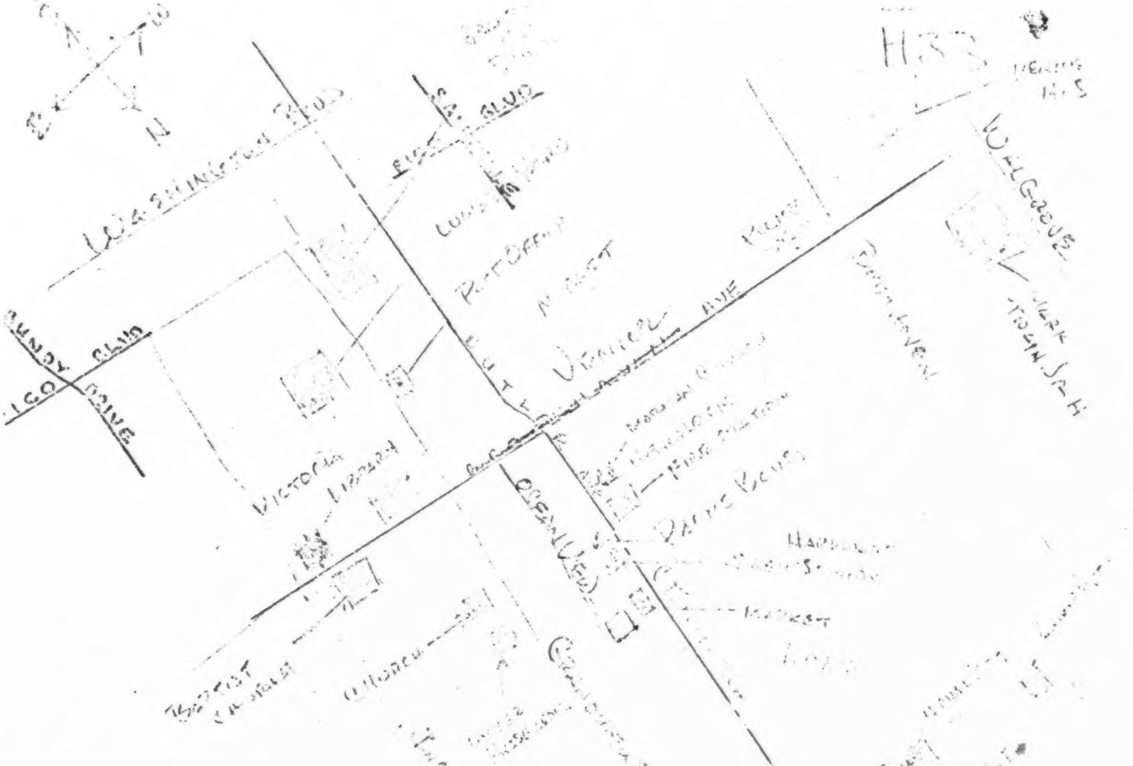

SA. BLVD
PICO
BLVD
DRIVE
AVE
NATIONAL BLVD
BARRINGTON
McLAUGHLIN
PALMS BLVD
CHARNOCK RD.
INGLEWOOD BLVD
VENI
base map coordinates
census tract sampled
major thoroughfares included in respondents' reference systems

Figure 1



N
S
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W
WASHINGTON BLVD
CULVER BLVD
BUNDY BLVD
DRIVE
VICTORIA
LIBRARY
POST OFFICE
MARKET
VENICE AVE
CULVER
OCEAN
FIRE STATION
MARKET
BAPTIST CHURCH
CHURCH
WALGROVE
H.S.S.
VENICE H.S.
MAR VISTA ELEM
NATIONAL
PARK
PARK
WESTSIDE MKT
CHARNOCK RD.
INGLEWOOD BLVD
VENI

Figure 2

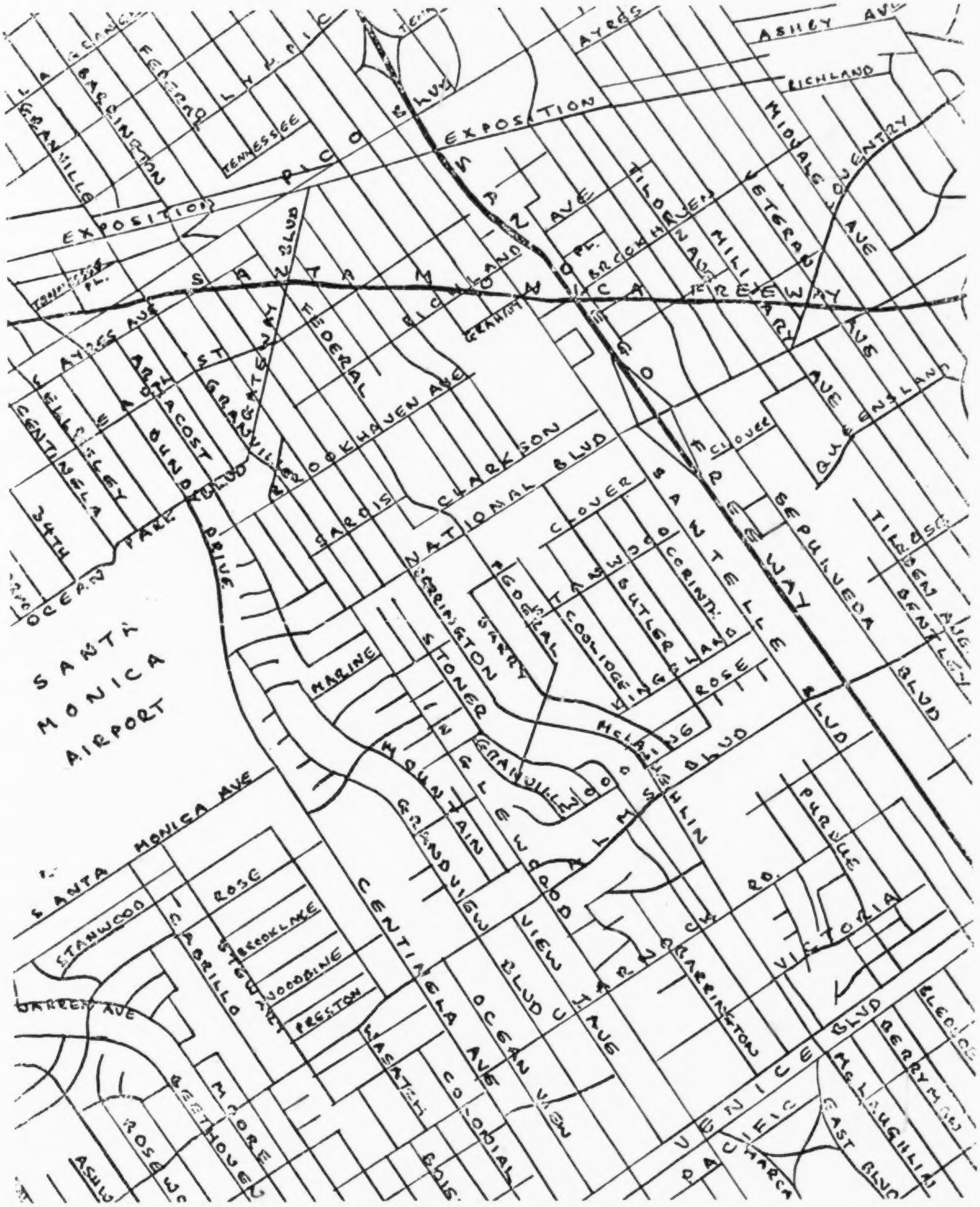
LA GRANGE
BARRINGTON
GRANVILLE
FEDERAL
TENNESSEE
PICO BLVD
AYRES
ASHLEY AVE
RICHLAND
EXPOSITION
EXPOSITION
MIDVALE
COVENTRY
AVE
TILDEN
VETERAN
MILITARY
AVE
BROCKHAVEN
PL.
AVE
TENNESSEE PL.
SANTA MONICA FREEWAY
SAN DIEGO FREEWAY
BUNDY DRIVE
FEDERAL
GRANVILLE
STEWART
ARMACOST
AYRES AVE
WELLESLEY
CENTINELA
34TH
BROOKHAVEN AVE
SARDIS
CLARKSON
NATIONAL BLVD
CLOVER
CLOVER
QUEENSLAND
SAWTELLE BLVD
SEPULVEDA BLVD
TILDEN AVE
BENTLEY
CORINTH
BUTLER
COOLIDGE
INGLEWOOD
BARRY
MCGAIR
GRANVILLE
STONER
BARRINGTON
MARINE
ROSE
MCLAUGHLIN
OCEAN PARK BLVD
SANTA MONICA AIRPORT
SANTA MONICA AVE
MOUNTAIN
GRANDVIEW
GRAND VIEW BLVD
INGLEWOOD
PALMS BLVD
MCLAUGHLIN
PURDUE
VICTORIA
ROSE
BROOKLAKE
WOODBINE
PRESTON
STANWOOD
CABRILLO
STEWART
WARREN AVE
CENTINELA AVE
WASATCH
COLONIAL
OCEAN VIEW
BARRINGTON
VENICE BLVD
PACIFIC
CHARCA
EAST BLVD
MCLAUGHLIN
BERRYMAN
MOORE
BEETHOVEN
ROSEWOOD
ASHLAND

Figure 3

may well be a consequence not only of environmental conditions but of the "life spaces," the "daily round of activity," of the residents themselves. As such it indicates that cognitive mapping is a useful technique for securing information about the variable quality of life in urban residential areas.

Notes

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2: PERSONAL SPACE

SOCIAL AND PERSONALITY CORRELATES OF PERSONAL SPACE (1)

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Abstract

A tape measure was used to determine the interaction distance between 100 male subjects and 2 male target persons acting as poll takers. Each target person was approached by 50 subjects individually after the subject had been asked by a female assistant to participate in an opinion poll. The poll was concerned with political and social attitudes. Information such as age, present living condition, etc., was also collected. The following month, 46 of these subjects were paid to take 3 personality tests: California Psychological Inventory (CPI), Marlowe-Crown Social Desirability Scale, and Machiavellian Five Scale. Analysis revealed that subjects who lived alone and those who saw their friends as conservative tended to stand further from the target person than subjects who had roommates and those who considered their friends as radical (1% and 5% level, respectively). The CPI Self-Acceptance scale was found to be negatively correlated (5% level) with interaction distance. A multiple correlation and regression analysis was performed on the data, and the limitations of this method were discussed.

Introduction

Many aspects of our daily interaction with the environment go by unnoticed, such as how we are affected by the buildings we construct and inhabit. Inasmuch as man is also part of this environment, it would not be unusual to find that, here too, certain aspects of the interaction between individuals are not fully attended to. Non-verbal communication is an obvious example of this inattention, where we react to the messages but are usually unaware that we are either sending or receiving them. That we do react to such things as facial expressions, body posture and position, for example, as non-verbal cues in our interactions, has been made quite clear by the work of investigators in the field such as E.T. Hall, who has also shown the importance of these "messages" in the process of communication.

The use of space is one way we communicate to each other and there are a number of investigators who believe this to be an area of great importance, such as Sivadon (2), who feels that the spatial relations of experience form the very basis of personality. Personal space is perhaps the term most often used to describe the distance an individual maintains between himself and others while interacting. This distance could be described as an "emotionally-charged" zone surrounding an individual which he perceives as belonging uniquely to himself. Needless to say, most of us are relatively unaware of this "zone" until it happens to be violated or intruded upon. Research has demonstrated the relevance of a number of factors related to an individual's "personal space", such as status, dominance, cultural background, interpersonal relationship, physical setting and personality of the individual (3). The present paper deals with two aspects of personal space; cultural background in the form of social perceptions and beliefs, and personality characteristics of the individual.

Research into the effects of cultural background on personal space has dealt mainly with cross-cultural differences (4,5,6); little attention has been given to sub-cultural differences. Hall postulates, however, that sub-cultural differences in the use of space do exist, and believes that these differences may be cause for concern (5). He states that "...in the major cities of the United States, people of very different cultures are now in contact with each other in dangerously high concentrations...(p.166)." Although he does not indicate specifically why these sub-cultural differences contribute to the dangers of high density living, it may be inferred that Hall is describing the increased probability of tension in this situation caused by conflicting spatial norms. In relation to these stresses, Hall is undoubtedly referring to groups with different ethnic backgrounds, such as Blacks, Whites, Italian Americans, Latin Americans, and so on. But, might not these differences in spatial preferences show up between any groups having divergent beliefs and life styles? For example, might not the groups typified by the Straight vs. Hip and Radical vs. Conservative stereotypes portray different spatial preferences? An attempt was made to answer this question through the use of an experimental questionnaire and experimenter ratings of subjects on dress and hair style differences (7). The questionnaire asked for self-ratings on the previously mentioned stereotypes and also requested sociometric data, such as where the person lived and how many people shared his living quarters. It was felt that a person living with others might tend to display less spatial needs, i.e., a smaller"zone", than a person living by himself. It was also hypothesized that Hips and Radicals would display smaller"zones" than Straights and Conservatives.

There has been a limited amount of published research dealing with the relationship between physical distance and personality. Hare and Bales (8) found, in a reanalysis of data collected from five-man discussion groups by Bales and his associates, that persons high on dominance (as determined by a short form of the "General Survey" used by Churchill, [9]) tended to choose central seats in the group and also did most of the talking. Williams(10) attempted to define the relationship between introversion /extroversion and conversational distance. He found that introverts kept people at a greater conversation distance than did extroverts. In this same light, Leipold (11) found that introverted and anxious individuals sat further from the decoy (experimenter) than did extroverted individuals with a lower anxiety level. (The anxiety level, as determined by the Taylor Manifest Anxiety scale, was significant for males but not for females in this study.) He also found a decreasing order of distance to the decoy in three conditions: stress, neutral, and praise. Dosey and Meisels (12) examined the interrelationships among three experimental measures of personal space in conjunction with a stress condition, three ratings on the Rorschach, and two exploratory questionnaires. The three measurements of personal space were listed as"...the placement of miniature silhouette figures (13); in sitting near or far from the experimenter(14); and in distance maintained when approaching another person (15)". The Rorschach was used to determine anxiety level and perception of body-image boundary. The questionnaires pertained to the use of space and the extent of touching and being touched by others since the age of 12. Neither the Rorschach nor the questionnaires proved to be of any significance in this experiment. The authors also found little consistency between the three spatial measurements and they cautioned against any"discussion of personal space without consideration of the method of assessment." The experiment did yield some positive results, however, which would indicate that (as Leipold [11] and Little [16] found) "spatial distances (tend) to increase under conditions of stress in the sense of reproof by others."

It was felt that the application of a personality test of much wider scope than those previously reported might help to define more clearly the relationship between individual differences and spatial preferences. The California Psychological Inventory (CPI) appeared to be the most logical choice from among the many tests available for several reasons (17). First of all, it is one of the most frequently used tests of the self-description type for "normal" groups(i.e., non-psychotic). The second consideration is that the 18 scales of the inventory are fairly easy to understand inasmuch as they refer to "folk" concepts of personality such as dominance, self acceptance, flexibility, etc. Two other self-description tests were also included, Marlowe-Crown Social Desirability and Machiavellian Five Scale, perhaps as much for their brevity as for their possible relationship to personal space. The Marlowe-Crown scale can be seen as a measure of defensiveness (in the sense of being unwilling to admit negative things about oneself, or to allow oneself to perform in ways that are not always considered socially desirable). The Machiavellian scale is designed to measure the extent of an individual's desire to control and manipulate others. There were no specific hypotheses made in relation to the personality tests.

Method

One hundred male caucasian subjects were chosen from among individuals walking along a ten-foot wide path directly adjacent to the main entrance of the University of California Library and Bookstore at Santa Cruz. This path was chosen because of the relatively light pedestrian traffic along it. (Most people use the adjacent large path and steps leading to the entrance of the building).

The Experimenter and his female Assistant located themselves a few feet up the small path from the main entrance with the male Target Person approximately ten feet further up the path. Holding a clipboard in one hand and pencil in the other, Assistant faced Experimenter, as if he were being interviewed, and awaited a Subject. When the path was relatively free of people and a single male Subject was approaching, Assistant would excuse herself from Experimenter and intercept Subject, saying: "Excuse me. I'm conducting an attitude survey of students, and I wonder if I could have a few minutes of your time? It's a very short questionnaire and shouldn't take more than five minutes to complete." (Wait for answer--if affirmative, proceed). (Smile) "That's fine. I have a few questions left to ask this person (look toward Experimenter), so why don't you go over to my assistant (motion toward Target Person who acknowledges by briefly raising his hand) who will take down some background information? I'll be through shortly and then we can complete the questionnaire." Two male Target Persons were used at alternate times and both were told to maintain some, but not constant, eye contact with Subject as he approached. When Subject stopped, Target Person took a tape measure from his rear pants pocket and asked him to place it against his chest. The chest to chest measurement was then recorded to the nearest half inch. The Subject was asked six questions dealing with his present status as a student, length of time at UCSC, age, and present living arrangements. He was also asked if he lived on or off campus and to choose from the following categories: (1) live alone (own apartment or cabin, etc.); (2) private room but live with others; (3) share room with one other person; or (4) share room with more than one person. It was felt that age and living arrangements might have some effect on personal space. Assistant then returned to Subject to administer the attitude questionnaire and Target Person moved about 10 feet away. (Experimenter left the area at this time.) Subject was asked to rate his political beliefs from 1 (very conservative) to 7 (very radical), and also to compare himself with the Straight and Hippie stereotype from 1 (mostly Straight) to 5 (mostly Hip). He was also asked how he would rate his friends in general along these same dimensions. A final question asked which of the living conditions described earlier were felt to be more desirable. This question was included in light of the fact that in some cases a student has little or no choice in whether he lives alone or with a roommate. After the questionnaire was completed, Assistant said: "one of the things we are interested in finding out in this survey is the distance for comfortable conversation. What I would like you to do now is to approach my assistant, again as if he were going to question you as he did before. Just move up to him until you find a position that is most comfortable and he will measure the distance again."

The concern with this second measurement was whether a person would act differently if he knew he was going to be measured. There were 80 subjects that indicated their willingness to participate as paid participants in a future experiment. Ten of these people could not be located the following quarter, and of the 70 that were contacted, seven turned down the request, 17 failed to show up for testing and 46 were tested. All subjects were contacted by telephone and asked if they would be willing to fill out several paper and pencil type personality tests at $2.00 an hour. The tests were administered in the Psychology Lab on the fourth floor of the main library at UCSC. The names of the subjects were recorded when they arrived at the lab and they were each given a randomized stack of tests with instruction to take the tests in the order given.

Results

Only one of the questions pertaining to the subjects' socio-political views tended to differentiate between opposing views on the basis of interaction distance. As Table 1 shows, subjects who felt their friends to be conservative stood, on the average, 4 inches further from the target person for the first approach than did those subjects who felt their friends were radical.

TABLE 1

Analysis of Approach Distance (in inches) Based on Perception of Political Belief of Friends

Item	Political Belief of Friends			
	Conservative	Radical	Diff.	t
N	7	71		
Mean of D1	29.0	25.3	3.7	2.08*

*p<.05

Analysis of the data also revealed a significant (1% level) negative correlation of -.394 between the first approach distance (D1) and living arrangements (the roommate variable), indicating that Subjects who lived alone stood further from the Target Person than those who had roommates. Table 2 indicates the mean approach distance for persons living alone and those living with roommates. The difference between these two categories of the roommate variable is significant at the 1% level with a t of 4.54 and 98 df.

TABLE 2

Mean Distance (in inches) of First Approach (D1) Calculated for Roommate Variable

Condition	D1	
	Mean	N
Live Alone	27.9	43
Live With Others	23.8	57
Total	25.5	100

The mean approach distance was 25.5 inches for Distance 1 and 23.5 inches for Distance 2 with a correlation of .473 (1% level) between the two measures. As Table 3 indicates, there was a significant difference between the first and second measure (.1% level), but apparently it made little difference who was used as the target person.

TABLE 3

Analysis of Variance of First and Second Approach Distance by Subjects Assigned to First and Second Target Person

Source	*df*	*MS*	*F*
Target Person (TP)	1	0.12	0.01
Trial	1	194.05	8.32*
TP x Trial	1	11.03	0.47
Error	196	23.28	

*p<.001

Two of the 18 scales on the CPI had significant correlations with the distance measurements. Sociability had an *r* of -.319 (5% level) with the second approach distance. Self-Acceptance had an *r* of -.350 with Distance 1, and an *r* of -.354 with Distance 2 (both at 5% level). A stepwise multiple correlation and regression analysis was performed on the data as an aid in increasing the descriptive and predictive capabilities of the CPI in relation to interaction distance. Very briefly, this analysis attempts to account for the variability of the sample (interaction distance in this case)by analyzing the interrelationships among the various independent variables (CPI scales). What it does, basically, is assertain which particular combination of independent variables can best account for the variability of the sample. This would seem to be a justifiable approach to the analysis of the CPI, for as Gough(18)says"...anyone who uses the inventory will soon discover that diagnosis must rest on patterns and combinations just as much as on individual high and low points (p.74)." (19)

Table 4 was prepared as an aid in understanding the combination of variables which are included in the equation for Distance 1. The table contains a selection of adjectives from those that Gough (18) found were correlated with his 18 scales of the CPI. Gough's results were based on a sample of 101 University of California fraternity students who had taken the CPI and then were each described by five of his peers on a 33-word adjective check list. In his report, Gough included the 20 adjectives most highly correlated with each scale (10 positive correlations for high scorers and 10 negative ones for low scorers). In the present study, it was felt that some selection from among the adjectives was preferable to including all 20 descriptions for each scale.

TABLE 4

Descriptive Adjectives Correlating with CPI Scales as Reported by Gough (18)

Scale	First Approach Distance	
	Near	Far
Self Acceptance	self confident, outgoing	submissive,tense, withdrawn
Femininity	feminine, sensitive	masculine,strong
Capacity for Status	restless, touchy	discreet,independent
Flexibility	easygoing, spontaneous	hard-headed,stern
Achievement via Conformance	considerate, reasonable	distrustful,rude, shallow
Dominance	self confident,	suggestible,submissive
Intellectual Efficiency	confident, reasonable	awkward, cold, queer
Sense of Well-Being	impulsive,restless,blustery	conservative,inhibited
Psychological-Mindedness	outgoing,talkative,sociable	aloof,unfriendly evasive,reserved, wary
Achievement via Independence	informal, pleasant	cautious,cool

TABLE 5

Multiple Correlation Analysis of Roommate Variable

Personality Scale	Alone	Roommate
Flexibility	Low	High
Self Control	High	Low
Tolerance	Low	High
Achievement via Independence	High	Low
Psychological-Mindedness	High	Low
Machiavellian 5	High	Low
Sociability	Low	High
Dominance	Low	High

Inasmuch as a Subject's living arrangement was found to correlate significantly with his approach distance, it was felt that a multiple correlation analysis of the roommate variable would be of interest. Table 5 contains only the direction of the results obtained from this analysis and, therefore, is presented as descriptive rather than predictive of whether one lives alone or with others (20).

Discussion

Before discussing the implications of the results of this study there are a number of limitations that must be considered. First, the results apply only to male caucasian students who happened to be walking alone near a university library and bookstore. Second, they apply only to a specific incident of being asked to perform the somewhat unusual task of walking up to an assistant poll-taker. The generality of these results is, therefore, felt to be somewhat limited until different variations of subjects, tasks and locations can be explored.

The results show that a relationship exists between an individual's living arrangements in regards to living alone or with a roommate and the distance he maintains while first approaching a stranger. This relationship could possibly be explained by considering an individual who lives by himself as a social isolate who has shown by his solitary habitancy a desire to maintain a good deal of distance between himself and others. The reciprocal relationship, of course, may be just as tenable, where an individual who lives with others has indicated at least to some extent, that he has no aversion to being close to other people. This is in line with Plant's(21) findings. He suggests, through his analysis of the psychological effects of crowding, that living under crowded conditions leads to a preference for being with people. His conclusions, of course, do not directly relate to individual distances but it would not seem too far off to assume that those who prefer being with other people will display smaller individual distances than those who prefer to be alone. Further investigation in this area might prove to be quite rewarding. It might also be interesting to look into the subjects' history of living conditions rather than just their present living arrangement and perhaps find some measure of crowding and degree of socializing.

As for the apparent relation between personal space and the perceived political aspects of one's peer group, the following is offered as a possible explanation. Intuitively, it would seem that the way one perceives one's peers would, to a large degree, determine how one reacts towards them, and inadvertently, towards others in general. Going one step further, if one of the connotations of the term "conservative" is considered as being a person who is reserved or "stand-offish", and this is how one's friends are perceived, the connection should be self-apparent.

The expectation that it would make a difference if a person knew his "space" was to be measured was confirmed, judging from the significant difference between the first and second approach distances. Thus, it would seem that not only must the "method of assessment" be considered before discussing the results of spatial measurements(12), one must also discern whether or not the subjects were aware that their space was being measured. As Hall suggests, "We treat space somewhat like sex. It is there but we don't talk about it." Possibly, when we stop to analyze our "spatial" motives the system breaks down, just as speech seems unnatural when we stop to analyze the words we are using. If the interpretation offered for this finding is correct, it would certainly call for a reevaluation of those studies where the subject was likely to know that the experimenter was concerned with spatial measurements (12, 15). Undoubtedly, there are other factors which may also have contributed to the difference between the two measurements. For example, the subject's familiarity with the target person changed somewhat from one measurement to the next, as did the precise location for each measurement. It may be said that the demand characteristics also changed; for the first approach the subject was told rather vaguely that he would have to answer some questions, while for the second approach he was told distinctly that his conversational distance was to be measured. There are a number of possible reasons why this could make a difference, one of which may be related to the perceived intimacy of the situation. In this light, the results could be seen as a confirmation of Argyle and Dean's "equilibrium" hypothesis (22). Briefly, they state that an equilibrium of intimacy is established early in a situation and is determined by a number of factors, such as: reason for the interaction, degree of smiling and eye contact, interpersonal distance, etc. If one of these factors change during the interaction, one or more of the other aspects of intimacy must change in the opposite direction in order to maintain the same degree of intimacy. Inasmuch as the subjects in the present experiment expected to be asked several questions of an unknown nature when they first approached the target person, the possibility existed for a fairly high degree of verbal intimacy in the situation. The demand characteristics of the second approach, however, did not include this expected degree of verbal intimacy, so the other factors would change towards a greater degree of intimacy to maintain the equilibrium that had already been established. This could help to explain why many of the subjects moved closer for the second measurement. Another possible reason for the difference between the two approach measures might be related to personality differences. Analysis revealed that subjects who scored below the mean (64th percentile) on the Flexibility scale of the CPI moved significantly closer (2% level [23]) on the second approach, whereas those who scored above the mean maintained about the same distance. Assuming that the scale does measure the "flexibility" of an individual, a possible explanation would be that low flexibility people, when they were first asked to participate, were more disturbed about being interrupted while going about their business than high flexibility people, and thus would probably stand further away to limit the intimacy of the situation. If this annoyance had dissipated somewhat by the second approach, then people of both high and low flexibility would maintain about the same distance for this measurement, which they did. At present it cannot be decided which, if any, of the foregoing explanations is the more veridical in accounting for the difference between the two measures. Further research dealing with the explanations set forth would hopefully be more decisive.

In relation to the aforementioned problem, there is one other issue that should be more closely analyzed when discussing "significant" differences in spatial measurements; the individual inaccuracy of establishing interaction distance. In other words, how accurately can an individual perceive the desired distance he wishes to maintain in an encounter. As with other psychophysical judgments (estimating the length of a line, etc.), there will undoubtedly be a certain degree of inaccuracy depending upon the situation. This inaccuracy is included under the heading of "error variance", which is simply all the uncontrolled sources of variance which influence the observation being made. The question then, is how much error variance is being contributed to the measurement by the variability in establishing a desired distance. A possible answer may be found in the results from Horowitz et al. (15) which are strikingly similar to those of the present study and display the same type of variability. He had ten male subjects approach a person until they just began to feel uncomfortable about closeness. In the first experiment, he found a mean of 22 inches (chest to chest) with a male target person and a mean of 24 inches, using the same subjects and target person, for the second experiment. The frontal approach to a female Target Person similarly increased from 17 inches to 20 inches, but as far as could be detected from the report, there was no discernable difference between the instructions given for the front to front approach in the two experiments. It seems much clearer in the experiment by Horowitz that the variation of the means may be due to the ill-defined limits of personal space. The issue at hand then, is whether the "expanding and contracting fields" postulated by Hall are accurately displayed by the individual to meet the needs of even subtle changes in a given situation, or whether in any given situation these fields have a certain degree of tolerance. Undoubtedly, both possibilities are true to a certain extent. However, the actual relationship between the variability of an individual's personal space in a situation more or less held constant on the one hand, and the variability due to specific changes in the situation on the other hand, cannot be described without further experimentation.

Although not very extensive, the findings from the correlation analysis of the personality scores were at least explainable. The description given by Gough (18) of the Sociability scale is quite similar to the explanation offered earlier for the correlation between the roommate variable and Distance 1. He says "Higher scores on the scale identify individuals of outgoing, participative temperament who seek out and enjoy social encounter. Low scores identify individuals who avoid involvement and who tend to fear or dislike social visibility." What we find then is that Subjects who score high on Sociability tended to stand closer on Distance 2 than low scorers on the scale, as would be expected from Gough's description.

Even more interesting than this is the description given for the Self-Acceptance scale (which correlates negatively with both Distance 1 and Distance 2). Gough says that "The goal...was to identify individuals who would manifest a comfortable and imperturbable sense of personal worth, and who would be seen as secure and sure of themselves whether active or inactive in social behavior [p.63]." From later research, Gough reports another facet of the scale: "The new element is one of ego-centrism--with high scorers being viewed as demanding, egotistical, opportunistic, and bossy (with clear manifestations of narcissism and indifference to others [p.63]..." He reports that a possible advantage of the high scorer on Self-Acceptance would be the ability to withstand stress, which was indeed the case in an experiment conducted by Lazarus, et al. (24). Of particular interest here are the two studies reported earlier relating stress with a need for greater personal space (Leipold [11], Dosey and Meisels [12]).

It would appear that the personality tests in general were rather insensitive to individual differences in the spatial measurements. This should, perhaps, be expected inasmuch as personal space does not bear a one-to-one relationship with any of the scales of the personality tests. The multiple correlation analysis may be seen as a possible remedy to this situation, but by using such a combination of scales, an interpretation of the results becomes quite complex. The adjective analysis provided by Gough can certainly help in dispelling this complexity. For example, analysis of the adjectives used to describe a person who stands near (Table 4) would certainly seem to indicate an extroverted nature, while the adjectives used for an individual who stands far indicate more of an introverted nature. This is the same relationship that both Williams (10) and Leipold (11) found between introversion/extroversion and conversational distance. Although this would appear to be a general finding, the predictive validity of the equation for personal space must await confirmation by cross-validation. It would be unwarrented, of course, to assume that the equation could serve as an overall predictor of personal space, for undoubtedly, different situations would yield different results. That this proposition is true and the extent to which situations must differ before the results are significantly changed, must be proven by further experimentation.

The multiple correlation analysis of the roommate variable, as shown in Table 5, can be seen as providing further evidence for the social isolate hypothesis. This hypothesis was offered earlier as an explanation for the finding that subjects who lived alone stood further from the target person than did subjects who lived with others. According to the correlation analysis, these latter subjects scored high on Flexibility, Tolerance, Sociability, and Dominance; all of which can be seen as measures of interpersonal adequacy (Dominance is not related to "domineering", according to Gough. The scale could perhaps better be labeled Leadership to avoid this ambiguity). Individuals who lived alone scored high on Self-Control, Achievement via Independence, Psychological-Mindedness, and the Machiavellian scale. The first two scales would certainly seem to attest to the self-reliance of these subjects, as would be expected for individuals who live alone. Persons scoring high on Psychological-Mindedness can usually be described as being somewhat antisocial, according to Gough, and as was explained earlier, the Machiavellian scale is a measurement of one's desire to control and manipulate others. Intuitively, it would seem that the descriptions offered by the regression analysis would, in many ways, fit the type of person one would expect to find living alone or with others. In this light the description of the roommate variable could be taken as an indication of the validity of the multiple correlation analysis, but we should not place too much reliance on intuition.

Perhaps a word should be said about the limitations of multiple correlation and regression analysis. To begin with, the analysis may capitalize on error variance, thus making weak relationships appear stronger. The results of any such analysis should, therefore, be considered tentative until further testing can establish the reliability of the regression equation. A second limitation, which was confronted earlier, is that the resultant equation can be quite difficult to interpret. This is due not only the number of variables in the equation, but also to the fact that each variable is usually assigned a different weight and therefore contributes a different amount to the equation than the other variables. One way to interpret the equation is to proceed as Gough did and obtain adjectival descriptions of subjects who have taken the CPI. These subjects can then be given scores on the regression equation being tested by applying it to their responses on the CPI. Then, by correlating these scores and the adjectival descriptions, a list of adjectives describing both high and low scorers on the equation can be obtained. An alternative method would be to select from among the list of adjectives supplied by Gough that correlate with each scale, as was done in the present study. Undoubtedly, the first method is preferable, but not always possible. A third alternative would be to prepare a table of the results, as was done in Table 5, indicating only the direction of the weighting each variable received in the regression equation. This method is attractively simple, yet still not as preferable as the first method. Understandably, the multiple correlation and regression analysis can be no more valid than are the variables used in the equation. As was mentioned earlier (3), there is some doubt whether tests such as the CPI are valid measures of personality differences. This doubt would caution against full acceptance of the findings related to the personality tests in this study without cross-validating the results with some other method of assessment. In other words, the finding that a significant number of individuals who displayed similar interaction distances in their approach to a stranger also responded similarly on the Self-Acceptance scale may or may not be related to how self-accepting these people are. Measurement on some criterion other than self-description to assess the self-acceptance of these individuals (if such a thing does really exist) would certainly clarify the issue.

In conclusion, it is felt that more emphasis should be placed on defining the situational determinants of behaviors such as interaction distance as well as on clarifying the interplay between the environment and invidual differences. It has become fairly evident that, just as the environment is affected by man's creations, so is man affected by the environment he has created (5, 25). If science is in any way to chart our destiny through this mutual man/environment relationship, it would seem imperative that there be a thorough understanding of how man is affected by his physical surroundings. As Sommer (25) concludes, "The long-range question is not so much what sort of environment we want, but what sort of man we want (p.172)."

- Notes -

(1) This study represents a senior honors thesis by the author and was supported by a faculty research grant awarded to Dr. David Marlowe for research into the social psychology of personal space. I am grateful for the advice and encouragement given by Drs. Marlowe and Pavel Machotka, and to David Keeber and Patrick Francis for serving as target persons. Special thanks are extended to Yvette Sanchez for her invaluable assistance in both conducting the study and preparing the written report.

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(19)The final multiple R with all ten variables used as a predictor for Distance 1 was .736, and for Distance 2, with seven variables, the multiple R was .725. The criterion for deciding the number of variables to include in the equation was based on the lowest standard error of the estimate, which in effect should give the equation with the best predictive ability. The equation for Distance 1 (based on the standard scores of the CPI scales), with a standard error of 3.40 inches, is as follows: 59.37 + 0.15 *Do* +0.20 *Cs* -0.48 *Sa* -0.10 *Wb* -0.26 *Ac* -0.09 *Ai* + 0.23 *Ie* +0.10 *Py* -0.20 *Fx* -0.11 *Fe*. A similar equation for Distance 2, with a standard error of 3.29 inches, is as follows: 27.03 - 0.22 *Sy* - 0.14 *Sa* -0.18 *Wb* + 0.28 *Re* +0.15 *To* +0.18 *Fx* -0.21 *Fe*. Interestingly enough, although the regression equations for the first and second approach distances are not identical (which was really to be expected, considering the significant difference between the two measures) there are a number of similarities between the two equations. For example, the two most powerful predictors (i. e., the first two steps in the stepwise regression) for both distances are the Self-Acceptance and Femininity scales of the CPI. Two other scales are also contained in both regression equations: Sense of Well-Being and Flexibility. The latter scale, however, is given opposite weightings in the two equations; i.e.,, negative for Distance 1 and positive for Distance 2. This assignment of opposite weightings is probably due to the significant change between the two measures for people scoring below the mean on the Flexibility scale, as was explained in the Discussion.

(20)The variables are entered in Table 5 in the order of their contribution to the multiple R, from top to bottom. Flexibility was the most important contributor with an initial correlation of 0.401 with the roommate variable. After the addition of the next seven variables, the final multiple R (having 0.630 as the lowest standard error of the estimate) was 0.651.

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A METHODOLOGICAL INVESTIGATION OF PERSONAL SPACE

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Hall (2) and Sommer (3) have suggested that the major determiner of personal space is the distance between people (the Interpersonal Distance or IPD).

Although there has been considerable speculation on the interaction between IPD and human behavior, there have been few successful attempts at developing objective measures of the effect. Most researchers have relied on techniques, such as self-report, which depend on the subject's conscious evaluation of his emotional state (4). Thus, Williams asked subjects to tell him when he had moved too close to them. In this case, the criterion for interaction was part of the subjective experience of the subjects and thus may have been biased by their perception of the task and the expected outcome.

Other investigators have carefully avoided self-report but their techniques are open to similar criticisms. Leipole (5) gave subjects stressful, neutral, and supportive information. He then asked them to enter another room and talk with another experimenter about the information. His measure of stress was the distance the subject placed his chair from the experimenter. Although this measure may have accruately reflected the mental state of the subject, it could have been biased through the conscious control of the subject. Similar criticisms may apply to the research reported by Sommer (6) and Horowitz et al (7).

Several studies have also confounded the subjective criteria of the experimenter with those of the subject. Hall (8) used shifts in the perceived loudness of a person's voice as a criterion for defining spatial zones. In this case the experimenter determined when there was a quantum jump in the voice level. Birdwhistell (9) varied the IPD and took motion pictures of eye movements and hand tremors made by his subjects. Although the techniques were potentially more objective than those mentioned above, the pictures were interpreted by the experimenter in a qualitative way which may have contributed a biasing effect.

Toward More Objective Methods

There is considerable evidence that the Galvanic Skin Response (GSR) can be used effectively to measure emotional responses. It has been shown to be a reliable measure of anxiety (10), sadness and mirth(11), general arousal level(12), emotional activity (13), and stress(14). In a study of IPD,McBride, King, and James (15) measured the GSR of subjects seated 1,3, and 9 feet from the experimenter. Although their results were not uniformly significant, they suggest that the GSR may reflect emotional changes as a function of IPD.

Several of the experiments reported above were based on the assumption that emotional responses to reduced IPD would be reflected in the general behavior of the subject. Although they used methods which might be biased by the subject's conscious control, this bias may be reduced by reinforcing the subject for avoiding the consequences of lowered IPD. One general class of such activities is information reduction tasks (16), in which the subject must perform some operation on the information given him. If the subject is given a good reason for not making errors (e.g. money, praise, or extra credit in his course), then there is a greater likelihood that the pattern of errors will reflect cognitive changes directly related to IPD and not simply bias of the form described above.

From the set of possible tasks which fit this description, we selected what Posner has called a four-bit reduction mode to a two-bit classification. This simple means that each subject heard two classes of random numbers which fell between 1 and 64. His task was to correctly classify them as either high and odd (odd numbers greater than 32) or low and even (even numbers less than or equal to 32). We predicted that error rate should vary inversely with the IPD. A more detailed explanation of this class of tasks may be found in Posner's (17) paper.

Finally, we used the semantic differential to provide some idea of the validity of this instrument for evaluating the effects of IPD on behavior. Self-report techniques are, of course, much easier to work with than more objective tasks. If it can be shown that the semantic differential provides similar information, this would add credance to the research findings presented by previous researchers and considerably simplify the task of collecting further data. Thus, the research reported below was designed to show that objective techniques can be developed to measure the effects of IPD on behavior, and to explore the validity of at least one self-report technique. Specifically, we hypothesized that GSR would vary directly with the IPD, and that errors in the information reduction task would vary inversely with the IPD. We also expected that the information collected with the semantic differential would be similar but not identical to the information obtained with the two objective measures.

Method

Subjects

The subjects were thirteen male and seven female students taking a course in introductory psychology at Colgate University.

Setting

The experiment was conducted in a long, narrow room (33x12x9 ft.). Experimenter 1 operated the polygraph which was to the right and behind the subject. Experimenter 2 scored the information-reduction error data and was seated in front of Experimenter 1, and in the extreme right portion of the subject's peripheral visual field. Experimenter 3 sat directly in front of the subject at the IPD designated for the condition.

Apparatus

GSR. The GSR was measured continually with a standard GSR electrode connection to a DMP-4A polygraph made by the E. and M. Instrument Company. The zinc alloy electrodes were attached to the right wrist and forefinger of the subject.

Information Reduction. The stimuli were 494 randomly-selected numbers between 1 and 64. They were presented on tape through headphones (Koss SP3) using a Craig Model 212 tape recorder. A constant background of low-level white noise was maintained through out the experiment.

Self-Report. The semantic differential consisted of five pairs of adjectives, each defining the endpoint on a seven-alternative scale. The adjective pairs were "secure-scared," "calm-nervous," "relaxed-stressed," "involved-detached," and "steady-jumpy." The form of the scale and the method of presentation are described by Osgood et al. (18)

Design and Procedure

The major independent variables were the rate at which the numbers were presented and the IPD. Each subject processed nine experimental tapes. A tape consisted of six groups of 16 randomly-selected numbers. Each group of numbers was paired randomly with one of six IPDs (1,2,4,8,16, or 32 ft.). Thus, each tape contained one group of 16 numbers at each of the six IPDs. The tapes were presented at each of three different rates: One number every three seconds, every two seconds, and every one second (designated the 1/3,1/2, and 1/1 conditions respectively). Thus, each subject processed 48 numbers at each rate at each IPD during the experiment.

The experiment was divided into two sessions, separated by at least one week. At the beginning of the first session, the subject was told that he was to do a number-categorization task while staring straight ahead at Experimenter 3 who would be studying his eye movements. The instructions suggested that the various other components of the task (e.g. the GSR and semantic differential) were related to the categorization task and his eye movements, although this was not stated explicitly. The instructions for the semantic differential were the same as those reported by Osgood et al. (19). The subject was also informed that if he had the fewest errors of all the subjects, he would win $5 and that subjects "who did well" would get extra credit in their psychology course. No precise definition of "doing well" was given, although the instructions implied it meant being cooperative and not making errors.

After receiving the instructions, the subject processed the practice tape which consisted of ten numbers presented at the 1/3 rate with an IPD of 4 feet. If he had no questions, the three 1/3 experimental tapes were presented. There were 30 seconds between each group of numbers during which the subject completed the semantic differential, and approximately two minutes between each tape.

The second session consisted of a recapitulation of the instructions, followed by the practice tape, and then the remaining six experimental tapes. The three 1/2 tapes were always presented first and the three 1/1 tapes last. The subject and Experimenter 3 were always of the same sex. The left or right position of each

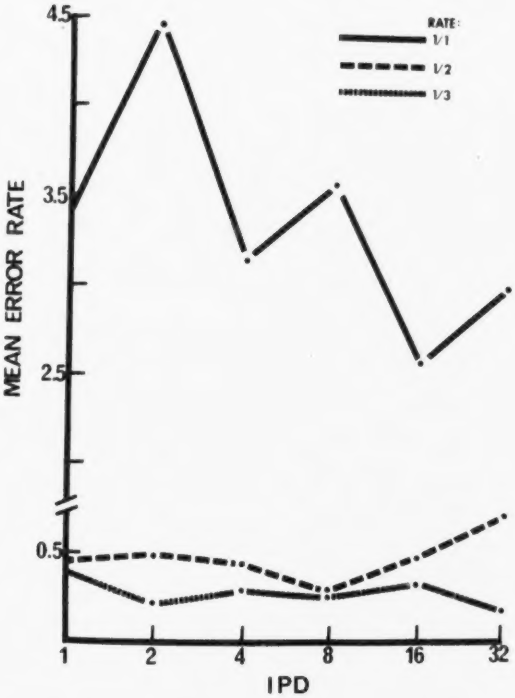

Figure 1. Mean error-rates from the information-reduction task as a function of the IPD and the rate of presentation. The IPDs are plotted according th the transformation: $x' = \log_2 x$.

adjective defining a scale and the serial order of each scale were counterbalanced across the experiment for each subject.

Results

Information Reduction

Figure 1 represents the mean error-rate from the information-reduction task, plotted against the six IPDs and the three presentation rates. There is a strong trend toward fewer errors with increases in the IPD for the 1/1 rate, but no apparent trend in either of the other two rate conditions. The results of a Treatment by Treatment by Subjects analysis of variance are shown in Table 1 (20). The effects of rate, IPD, and the interaction term are all significant, thus confirming the above observations.

Table 1. F-Ratios from the Treatment by Treatment by Subjects Analyses of Variance

Source	IPD	Rate	Interaction
Error Rate	2.95*	64.94***	5.95***
GSR	0.94	13.59***	2.88***
Semantic Differential			
Involved-Detached	2.07	0.98	0.85
Secure-Scared	2.64*	2.26	2.98*
Relaxed-Stressed	3.50**	4.62*	1.47
Calm-Nervous	4.04**	3.16	2.40*
Steady-Jumpy	1.48	5.02*	1.53

* Probability less than .05
**Probability less than .01
***Probability less than .001

Table 2. Results of Duncan's Multiple Range Test*

Rate	Significant Differences		
1/3	1-8ft.	1-16ft.	1-32ft.
1/2	2-8ft.	2-16ft.	
1/1	2-4ft.	2-16ft.	2-32ft.

* Entries represent pairs of IPDs for which the average GSRs are significantly different beyond the .05 level. The table does not show significant differences between different rates.

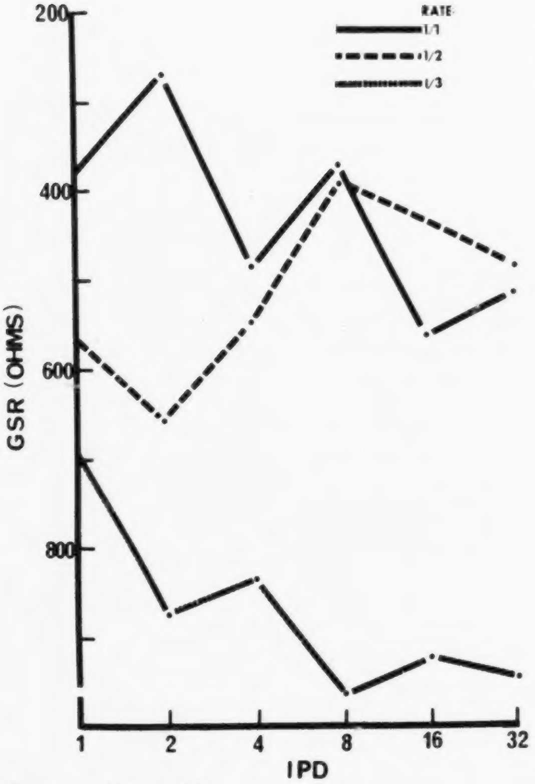

Figure 2. Mean GSR

GSR

The GSR measure for a particular trial was the average of ten measurements distributed evenly over a group of 16 trials. Since the time interval was different for each presentation rate, the ten measurements were separated by 25mm., 15mm., and 8mm. in the 1/3, 1/2, and 1/1 conditions respectively.

Figure 2 represents the average GSR scores plotted in the same manner as were the data in Figure 1. There are generally downward trends in both the 1/3 and 1/1 conditions and a slight trend upward in the 1/2 condition. A Treatment by Treatment by Subjects analysis of variance (Table 1) indicates that the presentation rate and the interaction term are significant, but that the main effect of the IPD variable is not. The results of a Duncan Multiple Range Test (21) which are shown in Table 2, indicate that IPD is generally a significant factor within each of the presentation rates, although all pairwise comparisons are not significant.

Table 3. Correlation-Coefficients and Frequencies of Significant Correlations among the Seven Dependent Variables

	1	2	3	4	5	6	7
1.		.78**	.78	.84	.16	-.02	.10
2.	18(17)***		.75	.77	.11	-.02	.15
3.	18(18)	18(16)		.75	.11	-.03	.07
4.	18(18)	18(16)	18(18)		.10	-.03	.12
5.	3 (0)	1 (1)	0 (0)	1(0)		.23	.04
6.	0 (0)	0 (0)	0 (0)	2(0)	5(2)		.08
7.	1 (0)	1 (0)	1 (0)	2(0)	0(0)	2(0)	

* 1=Error Rate, 2=GSR, 3=Detached-Involved, 4=Secure-Scared, 5=Relaxed-Stressed, 6=Calm-Nervous, 7=Steady=Jumpy

** Average of 18r's

*** The number outside the parentheses is the number of r's averaged together which were significant beyond the .05 level. The number of r's significant beyond the .01 level is shown within the parentheses.

Self-Report

Figures 3-7 show the average results from the semantic differential and Table 1 shows the results of the analyses of variance performed on the data for each scale. These results may be summarized as follows:

1. Detached-Involved. There is a trend toward greater detachment in the 1/2 condition as the IPD increases, but the trend is not significant.

2. Secure-Scared There is a trend towards greater security in all conditions as the IPD increases. This trend is strongest in the 1/3 condition.

3. Relaxed-Stressed. There is a significant trend towards relaxation as IPD increases. This trend is strongest in the 1/3 condition.

4. Calm-Nervous. There is a significant trend towards greater calmness with increased IPD. It is strongest in the 1/3 condition.

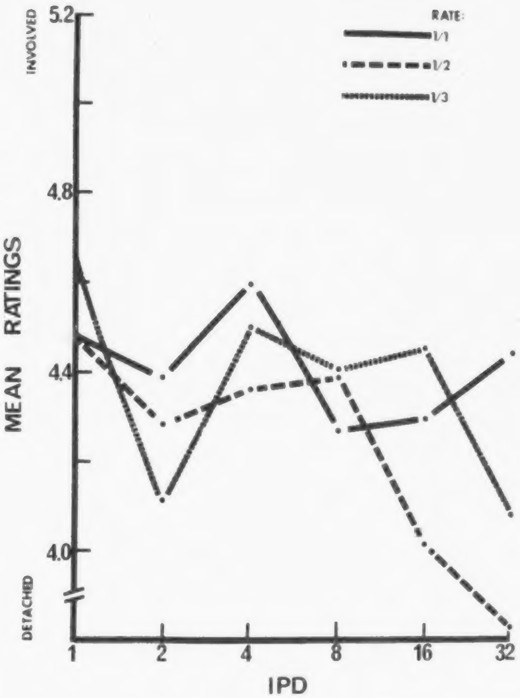

Figure 3. Mean Semantic Differential Ratings: Detached-Involved

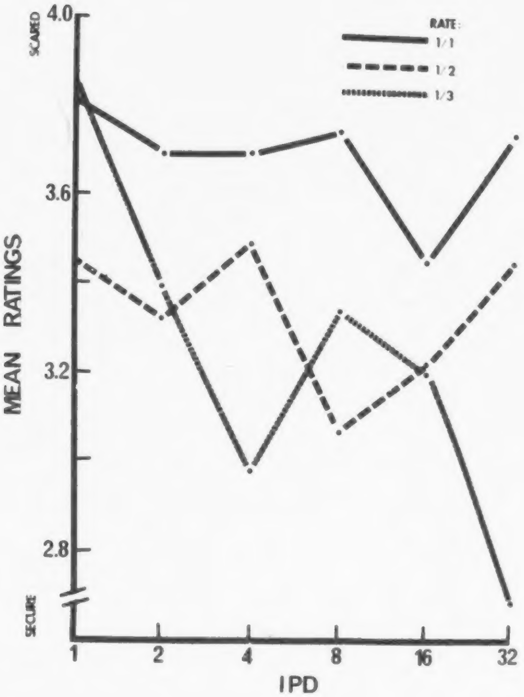

Figure 4. Mean Semantic Differential Ratings: Secure-Scared

5. Steady-Jumpy. Again there is a trend towards greater steadiness in the 1/3 condition with increased IPD, but this trend is not significant.

Comparisons Among the Dependent Variables

The data from the seven dependent variables were compared using Pearson Product-Moment Correlation Coefficients (r's). Since there are six IPDs and three information rates, there are 18 data points to be compared for each of the seven dependent variables. The upper triangular matrix in Table 3 represents the mean r's computed by averaging the 18 r's from the original data. The number of significant r's among each set of 18 r's are shown in the lower triangular matrix. The number outside the parentheses indicates the number of r's which are significant beyond the .05 level. The numbers within the parentheses indicate those significant beyond the .01 level.

There are three sets of dependent variables. Four of the five semantic differential scales have highly significant intercorrelations. All 108 of the r's between the scales labeled secure-scared , relaxed-stressed, calm-nervous, and steady-jumpy are significant beyond the .05 level and 103 are significant beyond the .01 level. The average r among them is .78. In contrast, only 12 of the 216 r's between these four scales and the other three dependent variables are significant beyond the .05 level and only one is significant at the .01 level. The mean r for these comparisons is .09. Thus the first four semantic differential scales appear to form a single cluster and thus to measure the same things.

The second set includes the detached-involved scale and the GSR. Although the average r between these two variables shown in Table 3 is only .23, five of the 18 r's upon which it is based are significant beyond the .05 level and two are significant beyond the .01 level. The mean r is .08 with the other 5 dependent variables. It seems reasonable to conclude that the detached-involved scale and the GSR contain some information in common which is not contained in the other five variables.

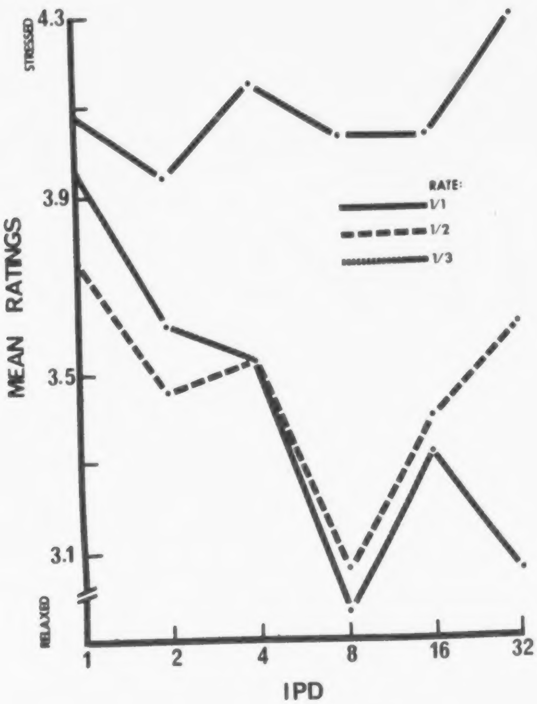

Figure 5. Mean Semantic Differential Ratings: Relaxed-Stressed

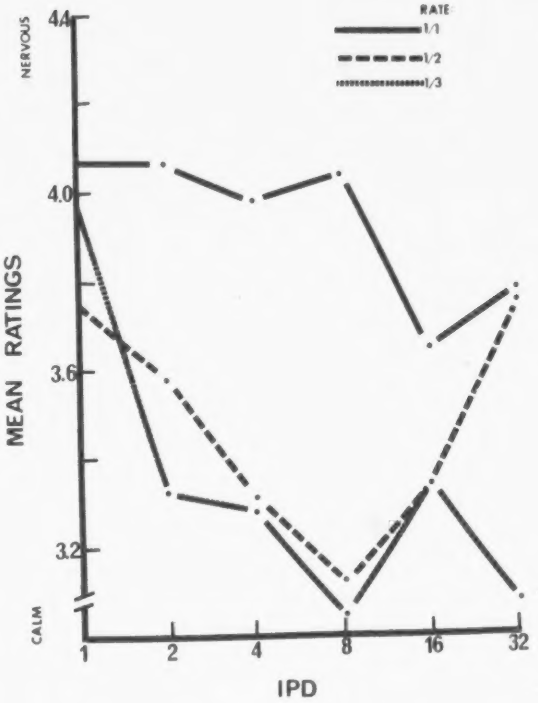

Figure 6. Mean Semantic Differential Ratings: Calm-Nervous

Finally, the error rate correlates with very little else. Seven of the 108 r's between it and the other six dependent variables are significant beyond the .05 level and none is significant beyond the .01 level. The mean r is .09.

Discussion

The first purpose of the experiment was to explore two relatively objective measures of the effects of IPD on behavior. The error rate in the information reduction task indicates that it does contain information about the effects of the IPD, but that most of the information is in the 1/1 condition. The data suggest that there is a relatively high threshold which must be exceeded before the effect of the IPD will be reflected in the error rate. Careful thought should therefore be given to the difficulty of the task before error rate is used as a measure of the influence of IPD on behavior.

The results from the GSR measure are also encouraging. Both the 1/1 and the 1/3 rates show lowered resistance as the IPD is decreased. This suggests that the GSR may be more sensitive than error rate to small changes in the emotional state of the subjects. For this reason it would seem best to use GSR in situations where only one of the two measures can be employed.

The second purpose for the experiment was to evaluate the substitutability of the semantic differential for the two more cumbersome measures which are less open to biases of an extraneous sort. In general the data indicate that there is some overlap in the information contained in the three methods, but that they are not equivalent to each other. With the exception of the involved-detached scale, the semantic differential was most effective in showing the effects of IPD on the subject when the task was easy. The GSR measure was most effective at the easiest and the most difficult tasks, and the error rate measure was most effective at the most difficult task. Although these data are not conclusive, they do suggest that

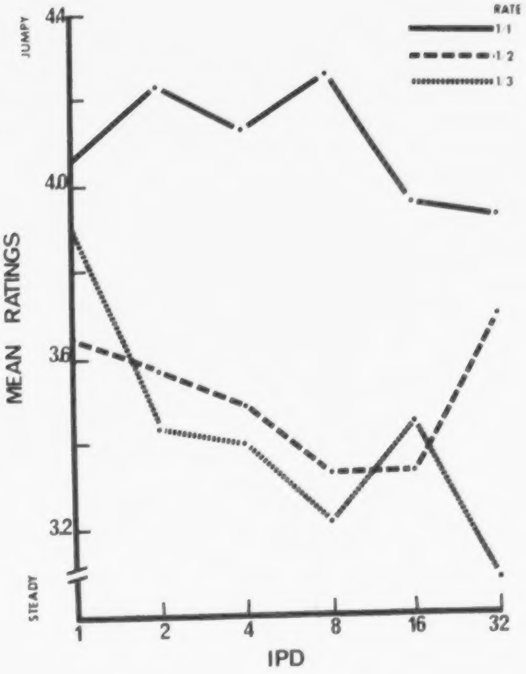

Figure 7. Mean Semantic Differential Ratings:
Steady-Jumpy

each method taps a different component of the subject's reaction to encrouchment on his personal space.

This hypothesis is also supported by the results of the correlation analysis presented in detail above. The very low correlation between the three sets of dependent variables, and the reasonably high correlations within each set, indicate that all three measures of emotional reaction are necessary to adequately describe the subject's responses to variations in IPD. We therefore suggest that future research on personal space include all three sets of variables in order to provide an adequate profile of the subject's emotional state.

Notes

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CONCEPTIONS OF SELF AS INDIVIDUAL ORIENTATIONS TO THE SPATIAL ENVIRONMENT

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Introduction

The conceptual context underlying this research study can be introduced by reviewing the positions advanced by some of the contributors to last year's EDRA conference. Altman suggested an ecological conception of man's interaction with the environment (1). He notes that behavior occurs at many levels, as well as in complementary, substitutable, coherent sets. Wicker notes that, while individual behavior varies, most of the time it appears to be consonant or compatible with the settings in which it occurs. The measure of fit between behavior and setting is referred to by Wicker as Behavior-environment congruence (2). This concept leaves open the question of what, or how, one ascertains the appropriate standards and conditions of congruence.

Markman offers a possible answer in his argument that man's interaction with the environment is in large measure dependent on his characteristic mode of being in the world (3). This is amplified by Craik who believes that individuals seem to display enduring styles of relating to the environment (4). The basis for such stable, enduring, and coherent patterns of behavior is suggested by DeLong in his discussion of the complexity reduction functions of coding behavior (5). His basic position is that the reduction of environmental complexity through coding insures a degree of stable predictability necessary for an organism to successfully function in the environment.

Codes, as classification systems, are the basic elements for dealing with the environment and, hence, underly the configurations of attitudes, values, beliefs, and sentiments which McKechnie labels "environmental dispositions" (6). It is generally agreed that there is no necessary connection between the nature of things or ideas and the units we use to classify them (7). Yet, codes, as systems of classification, tend to be subject to conventional and regular patterns of use. This is critical when we consider the use of coding systems in interpersonal communication (8). The essential point to be made here is that classification, orientation, and responses to the environment exist within the context of a social environment where mutually agreed upon and shared, conventionalized ways of coding the environment are basic to the communicative needs of individuals engaged in social interaction.

Another implication of the above concepts is that an appropriate model of man-environment interactions must recognize the interdependency of individual differences as well as the systemic, social regularities. That is, an individual is not just a collection of psycho-social attributes; rather, these attributes are configured in particular, interdependent ways with respect to each other as well as to the larger socio-cultural milieu.

The above discussion suggests that a model of man-environment relations should be able to relate a person's attitude and belief configurations to, and as the basis of, his interactions with the spatial environment. In addition, we would want to respect the collective, social, systemic character of those interactions with the environment. Such a model could be seen as deriving its form from the social milieu, and having its existence in the environmental orientations of the individual. Its focus would be on those ways the individual was disposed to, or related the environment to himself.

The research that follows pursues the above formulation of man-environment relations. It accepts as its basic position the following concepts:

1.) Behavioral responses to the spatial environment must be a function of how the individual conceives the "meanings" of a given environmental display (9). (Or, the importance of the spatial environment for an individual must be evaluated in terms of what is relevant about a particular setting as he conceives it.);
2.) How an individual conceives a given environment will be a function of:
a. prior experience with the given setting, or some comparable environment,
b. the social context in which the particular setting is encountered,
c. the situational needs, objectives, and relations of the individual to the situation as he understands them (10);
3.) Behavior and experience of the environment exist within the context of a patterned, coherent, stable, and mutually shared social system. It is due to these characteristics of consistency that individuals are able to interact with one another and have similar interpretations of behavior and experience (11);

4.) Human behavior occurs largely within the built environment. Consequently, the distribution of actually occurring environmental elements is finite, and the range of interpretations of those elements is related to that distribution.

The Study

Description-- The efforts of this study were directed towards providing exploratory evidence and confirmation of the relationship between responses to the spatial environment and characteristics of individual "frames of reference" as indicated in descriptionsof self. It was hypothesized that differences in expressed self-concepts would be reflected in consistent variations in orientations to the spatial environment.

Setting and Methods--A questionnaire, adopted from an earlier study (12), was administered to nearly 200 students living in dorms at the Pennsylvania State University campus. Respondents were not specifically selected. Instead, seven dorms were chosen for the study. There are four major dorm complexes on the Penn State campus. One female dorm and one male dorm were selected arbitrarily from three complexes. The fourth complex was all male and the seventh dorm included in the study was located there. The useable sample consisted of 165 subjects.

Questionnaires were all distributed in one evening by a team of investigators. Each person was given 28 questionnaires and instructed to randomly knock on doors, giving out approximately the same number of questionnaires on each floor of the dorm. Hence, the sample was essentially random, and was assumed to be basically representative of P.S.U. students living in dorms.

Identification of 'Self-Concept" Groupings--Preliminary analysis consisted of developing coding categories for the open-ended questions, and in analyzing responses to a self-concept question so that contrasting personal frames of reference could be compared in relation to responses concerning various orientations to the spatial environment. Specifically, the question asked went as follows:

> "Self is a word generally used to describe those characteristics a person associates as being descriptive of his own personality or behavior. While this is a very complex concept, we would like for you to use the space below to describe yourself briefly."

Frequencies of various responses were noted initially, and a classification scheme based on Gordon's work was employed to develop a preliminary grouping of responses (13). From this analysis, four thematic dimensions of self that seemed to be most common in the responses were derived. These four themes were then each structured as bi-polar concepts and each respondent's 'self' answer was scored in terms of the four themes. For each dimension, or theme, the respondent received a score of either one or two depending on to which pole his response seemed to fall. In cases where self responses were too abbreviated or ambiguous, the respondent was given a score of three on all four dimensions even if only one of the four dimensions was not ascertainable. Nineteen respondents were so rated. Another 23 did not answer the self question and were given scores of 0. The four dimensions of classification were:

1.) Inner-directed versus Outer-directed - assessed primarily by whether attributes of self were those measurable according to internal criteria versus those more likely to require some external social confirmation or approval.
2.) Interpersonal confidence versus Interpersonal anxiety - whether the social environment is typically approached freely and openly versus approaches with apprehensiveness.
3.) Interpersonal style versus Personality traits related to social interaction - descriptions of the ways or manner of interacting with others versus descriptions of the attributes of self manifested in social interaction.
4.) High-esteem versus Low-esteem - (high self-esteem could include negative comments if they related to attainment of personal standards and not directly related to social standing or credibility.)

Including the 0 and 3 rated groups, 16 different combinations of the four dimensions occurred (i.e. 1111, 1211, 2211, etc.). From these, the two extreme groups--those who received all 1-scores and those who received all 2-scores--were selected for comparative analysis on the spatial behavior and attitude questions. These were chosen for a variety of reasons--it was convenient, simpler, and the most direct way to test the hypothesis. Since there was no way to weight the four dimensions, any attempt to rank the 16 groups would have been very spurious (i.e. which is more like a respondent with all 1's--one with 1112, or 1121, or 2111, etc.?).

Using the first dimension to distinguish the two groups, we shall subsequently refer to them as the Inner-directed group (I.D.) and the Outer-directed group (O.D.).

Content of Self-Concepts--There were 11 respondents in the I.D. group and 15 in the O.D. group. The self responses of both groups were found to be classifiable according to a few categories that were approximately equivalent in terms of thematic content. There were clear, yet subtle, differences between the two groups. Inner-directed respondents indicate a rather active orientation to others which they qualify through statements of "independence". A more passive social orientation is expressed by O.D. respondents (i.e. "easy to get along with"). They also admit to constraints affecting their interactions with others, and seem to try to explain or justify them.

Personality descriptors of I.D. respondents are also more assertive as compared to O.D. comments which occur less and are more typically statements of socially valued attributes they feel they possess. Outer-directed comments about role and social involvement seem to be more ambivalent and conformist than the "positional" statements of I.D. respondents.

In general, O.D. respondents seem to indicate a fairly high sensitivity to how others respond to them and are less inclined to make assertive statements about themselves that might identify them as being very different from other people. In contrast, I.D. respondents are more assertive, specific, and indicate a propensity to see themselves in contrast with others.

Analysis of Results

Overview--Table 1 lists the responses of the questionnaire and the respective percentages of the population and the two groups to those questions. The difference in percentage points between the two groups and the population is also indicated. Figure 1 shows the percentage responses for each group compared to the population's response percentages which have all been set to zero. Figure 1 clearly illustrates the tendency for Inner- and Outer-directed respondents to use and respond to the spatial environment in rather different ways.

Figure 2 shows the actual response percentages of the two groups and the population. The graph appears to indicate that the response patterns of the two groups follow, approximately, the responses of the population, but shifted above and below respectively, to the pattern of the population's responses.

The implication of this result is that there is some basic, or "average" pattern of conception, response, and interaction with regard to features of the spatial environment. The upward and downward shifts of the two groups, in turn, suggests that the degree of variation in responses is an indicator of the range of environmental responses due to differences in the characteristic personal modes of orienting to the spatial environment. Since the two groups were differentiated solely on the basis of self-concept responses, these orientations would appear to be manifestations of the respondent's personal, self-based frames of reference.

What the character of this apparent structural relationship between environmental responses may consist of has yet to be evaluated. However, it does seem reasonable that such a structural pattern might exist. It would be logical purely for reasons of cognitive and behavioral efficiency; but, the fact that the spatial environment is largely a "built" response to social needs and that social behavior itself tends to be highly patterned provides a basis for serious consideration of the possibility of interdependent conceptual models and patterns of responses to the spatial environment.

If we can tentatively accept the notion of an interdependent environmental response pattern, and of individual variations of these patterns as a function of frame of reference, then a logical next step would be to regard those responses which diverge significantly from the generally observed pattern as indicators of environmental responses where differences in self orientations are most salient.

Analysis of Figure 2 showed that significantly divergent responses occurred mutually for both groups on four questions. These four are discussed below:

1.) Response 1--In this question, the subjects were asked to indicate any other rooms with their dorm that they had lived in prior to their present location. In the I.D. group, it was found that virtually all respondents who had lived in other rooms were not now living on the same floor that those prior rooms were located on. By contrast, only 20% of O.D. respondents were on a different floor. In other words, they moved laterally whereas I.D. respondents moved vertically. This is quite logical. Peer group associations tend to be most salient among those living on the same floor, hence O.D. respondents are probably moving to enhance their position within their group while I.D. students reflect their greater independence by moving vertically to more desired locations within the dorm.

2.) Response 4--Here subjects were asked why they chose their room. Their responses provide additional information with regard to the above. Forty-one percent of the responses of I.D. students are non-positive reasons (negative or neutral), but all of the O.D. responses were positive. Thus I.D. responses are far more likely to indicate reasons for moving out of their previous rooms. This reinforces the idea that I.D. students are asserting a degree of social independence while O.D. respondents are responding spatially to existing social ties.

3.) Response 18--This question dealt with changes in the dorms. Inner-directed students tended to refer to changes that were social in content while O.D. students noted changes that were non-social. At first one might expect the opposite. However, if one is Outer-directed, the criterion of social stability is likely to be crucial. Therefore, they are more likely to attend to those things in the environment which maintain and reflect the reference group. Furthermore, we should expect a fairly consistent and positive conception of change, reflecting the O.D. student's group oriented frame of reference. This is confirmed in that all responses were positive and 67% referred to changes in dorm policies. (In contrast, I.D. responses were 28.5% negative and only 14% referred to dormitory regulations while 57% referred to various changes that were social in character.) It should also be noted that the high proportion of 'dorm policy' responses by the O.D. students is consistent with their orientation to external authority.

4.) Response 22--This question asked the respondents to indicate what they considered their personal turf or territory. Inner-directed subjects tended not to give non-personal areas as responses (only 27%) as did O.D. subjects (66%). The more general, non-personal responses of O.D. students are consistent with their peer-group orientations. Responses of the I.D. students are primarily either areas within the dorm or a denial of any sense of territory. The social independence of I.D. students could well give them a sense of not having any territorial constraints, or alternatively, that it is limited to those areas residentially personally occupied.

With regard to the concept that high divergence reflects factors more influenced by personal orientations than others, it can be observed that all four of the above responses refer to relationships to one's residence (i.e. dorm or dorm room). They include its definition (22), movement within it (1), reasons for selection (4), and perceptions of change (18).

Analysis of Responses--the responses were grouped into four general areas concerning people's interactions with the spatial environment. They include; 1.) distribution of social relations, 2.) use of the environment for social contact, 3.) attitudes, and 4.) preferences concerning the environment.

1.) Distribution of Social Relations--Inner-directed respondents differed from O.D. subjects in that they tended to have fewer close friends but more acquaintances at locations of varying distance from their dorm rooms. They also tended to have more friends at more distant locations while O.D. subjects indicated a fairly sharp drop in the number of close friends and acquaintances with increasing distance from their rooms. This relationship was also indicated in I.D. responses stating that most of the people they visited with lived outside their dorm while the converse was true of O.D. students.

Though the levels, or intensity of social interaction was the same for both groups, I.D. students indicated that relatively more social contacts occurred in or near their dorm rooms while O.D. students indicated just the reverse. That O.D. students would tend to have a more proximate distribution of friends and acquaintances can be anticipated from their other-directed peer group orientations. However, it is seemingly curious that they should report having more interactions with others in areas outside the dorm than within.

Discussions of subsequent responses will provide some insight and qualifications on this result. At this point, we can suggest that the social independence of I.D. students would lead them to be both more comfortable in interacting with others, regardless of location, and more likely to report more contacts in the dorm simply due to proximity factors. In contrast, we might hypothesize that O.D. students might seek to enhance status relationships by eliminating "home turf" issues which could inhibit the willingness of themselves and others to make contact.

2.) Use of the Environment--Responses concerning what spaces on campus were used most by the respondents, and to where they spent their free time provide some confirmation of the above hypothesis. Outer-directed respondents indicated recreation areas most frequently as the public spaces they used most, whereas I.D. students noted spaces in the dorm complex (cafeterias, lounges, game rooms, etc.). Both groups noted the student union building second most frequently. In addition, I.D. students gave proportionately higher responses to all other public spaces on campus with the exception of recreation areas and the library.

Outer-directed students tended not to indicate much useage of dorm areas. With respect to where their free time was spent, however, O.D. subjects indicated that more was spent within the dorm complex than outside of it. The reverse was true of I.D. respondents.

The responses of both groups are consistent with the hypothesis advanced above concerning "home turf" issues. Inner-directed respondents indicate useage of a wider variety of spaces, and reflect that variety in the spatial distribution of "free time" activities as well. The O.D. respondents indicate a higher use of dorm areas for free time activities, but do not say that the dorm is a public space they use a great deal. This may be related to their responses indicating that more of their interactions with others occur away from the dorm.

Two related conceptions of this relationship can be advanced. First, it is possible that socially "neutral" settings are more significant to O.D. subjects in the sense that they are "used" by them as important settings for social encounters. Secondly, perhaps dorms are included in the O.D. student's conception of the spatial "range" of relevant peer groups, and as such are not considered as "public" spaces in the same sense as areas outside the dorm. Hence, if these concepts have validity, it would be possible for O.D. students to spend large amounts of their free time in the dorm while still conceiving public areas outside the dorm as those one makes high use of.

Where people first met their closest friends can also provide some indication of how the environment is used. The two most prevalent responses of O.D. students were that friendships were initiated in the dorm or through mutual friends, thus reinforcing the importance of peer group associations in their social relationships. To the extent that the locus of the peer group spatial boundaries coincide with the dorm areas, there is a likelihood that mutual friends exist within the dorm (as evidenced in the earlier finding that more close friends of O.D. students live in the dorm). Inner-directed students indicated the larger "dorm complex" areas as well as social ties existing prior to their arrival at the university as the major sources of their close friends. Again, this reflects both the wider ranging spatial distribution of significant social involvement and the relative independence from dorm-based peer groups of I.D. students. It also suggests a possible explanation as to why their close friends are more widely distributed in space.

3.) Attitudes Concerning Attributes of the Environment--It was noted in the discussion earlier that reasons for selection of one's dorm room were all positive for O.D. respondents whereas I.D. responses included many non-positive reasons. In addition, I.D. responses tended to be social in content while O.D. responses were largely spatial (e.g. convenience, location, etc.) Of those O.D. responses that were socially oriented, 5 out of 6 referred to specific individuals. In other words, social reasons for room selection among O.D. students were oriented almost entirely to preferences for a specific person as a roommate.

Asked whether they felt "part of" the dorm or whether it was "just a place to live", O.D. respondents tended to say "part" while I.D. respondents were split (45% said "part" versus 60% in the O.D. group). When one considers membership in campus organizations as a possible alternative to dorm-based peer groups, the difference between the two groups is even more pronounced (80% of O.D. students said either "part" or belonged to some organization compared to 55% for I.D. students).

In addition to feeling "part of" the dorm, O.D. respondents tended to say that other dorm residents were similar to themselves, and that the dorm itself was "one of the best" on campus. Inner-directed students saw less similarity with others in the dorm and rated the dorm as only "average". This is consistent with their propensity to say that the dorm is "just a place to live". It should be noted that many of the I.D. students are quite happy living in the dorms which may explain why there were a number of them who felt "part" of the dorm (even though they rated it lower and say others as dissimilar--thereby further confirming their relative independence).

4.) Preferences Concerning the Spatial Environment--Inner-directed subjects indicated spaces that they liked most on the campus which appeared to be characterized by having activities occurring within them that were public, social, unstructured, and less commonly the types which nearly all students come into contact with (unstereotyped areas). Outer-directed students also tended to give social area responses, but the areas mentioned were those more frequently used by most all students (e.g. student union and library), and they tended to be areas with structured activities.

With respect to areas preferred for meeting with friends, I.D. students preferred each other's rooms over other places whereas O.D. students tended to prefer other places. Forty percent of the O.D. respondents ranked their own rooms last compared to only 9% of I.D. students.

If respondents said they preferred areas other than each other's rooms to meet, they were asked to list those places. The character of the places list was similar to those they had noted as those they liked best. In addition, the areas for O.D. students tended to be those where they were "doing something"--i.e. where there was an ongoing activity.

Respondents were also asked what type of residence they would prefer if they had a free choice. Responses were similar for both groups in terms of preferences for dormitory versus off-campus housing. (Providing evidence that I.D. students can be satisfied with dorm living even though not necessarily oriented to it socially.) Among those indicating a preference for off-campus housing, I.D. students indicated that they would like 1 to 3 roommates while O.D. students preferred 3 or 4. Thus, it would appear that not only do O.D. students prefer spaces where there are ongoing, externally structured social activities, but they also prefer larger groupings. This is consistent with their propensity to have more friends in the dorm setting, and it may bear some relation to their basic social orientations to peer groups. Inner-directed respondents, on the other hand, indicate preferences for situations with less pre-structuring and more idiosyncratic in character--reflecting their particular self-interests.

Expressions of what about the dorm environment was liked most and least by respondents also provided indications of fundamental differences in basic social orientations and conceptions of the environment between the two groups. Similar results were found in their conceptions of changes that had occurred in the dorm while they had lived there. Inner-directed respondents indicated that interpersonal, social factors were most important to them in both positive and negative values associated with the dorm as well as in their conceptions of change. Outer-directed respondents indicated non-social factors such as spatial and policy attributes of dorm living as important values and changes.

Thus, on one hand, we can see evidence that O.D. students are socially integrated within the dorm community, and on the other hand they do not respond to or evaluate that setting in terms of social variables. It has been noted previously than an outer-directed reliance of self upon an external social involvement with others would encourage a high valuation upon perceptions of stability and consistency of structure and relationships. This would also tend to explain why social factors are not noted among evaluative critical judgments related to the environment and changes occurring within it. There seems to exist a propensity to perceive and respond to the spatial environment in ways related and conductive to one's orientational frame of reference and resultant social needs.

Outer-directed respondents, by orienting to external reference group frames of reference, obviate the need to formulate extensive models of the social characteristics and needs of various spatial settings. For them, the critical factors seem to be more the relative positions of the involved individuals that influence how they respond to situations and spatial settings. Inner-directed subjects appear to conceive various settings as having certain characteristics and respond to those settings and the people in them according to those conceptions. Thus, the results indicate that the individuals in the two groups relate and respond to various settings in different ways--possibly, even to the point of having entirely different conceptions of them.

The last question to be considered asked the respondents to indicate their conceptions of their personal turf or territory. Inner-directed respondents tended to indicate either a specific dorm area, or to deny any sense of territorial boundaries. Outer-directed students also gave a substantial number of "dorm" responses plus a considerable number of rather general areas as responses. Only one O.D. respondent denied any sense of territory, and two-thirds of O.D. responses referred to areas that were general and non-personal in character.

These results, again, suggest individual conceptions of the spatial environment that are congruent with, and supportive of, personal orientations. Inner-directed students, as we might expect, give rather personalized conceptions of territory. It is not inconsistent for them to deny having a sense of territory for, having a basically social orientation and conception of the environment, they are able to either reject their present living situation as being a reflection of their concepts of self, or they might feel that it is a meaningless statement since they relate to all settings in terms of their congruence with concepts of self.

Discussion

In one of the earlier collections of articles focusing on man's relations with the physical environment, Kates and Wohlwill take the position that man-environment relations are greatly influenced by cognitive factors (14). In this study, preliminary, yet substantive evidence has been presented to support that view. The overall pattern of the responses supports Altman's conception of an ecological relationship, and Craik's of 'enduring styles' of relating to the environment (15). The results are also consistent with the concepts of self- and cognitive-consistency (cf. Lecky (16), and Turner (17).

Turner asserts that the basic values, goals, and aspirations of an individual provide framework for self-concepts which must then be edited in social interaction so that attributes assigned him by others do not diverge to an unworkable extent from his own conceptions (18). In this study, those responses which were most divergent from the population's responses (see figure 2) indirectly support Turner's argument in that their maintenance was not likely to affect one's relations with others. In addition, the commonality of their spatial referent (i.e. where one lived) supports the idea of consistent environmental dispositions suggested by both Craik and McKechnie (19).

Turner also suggests that interaction may be divided into identity- and task-directed orientations. He believes that identity orientations occur when individuals become concerned about other's attitudes toward himself (20). At another level, numerous studies have indicated the importance of one's residence to identity, or self-image (21). In this context, the fact that attitudes and behaviors related to residence should be the most divergent between two groups identified through self-concept differences is quite consistent.

The analysis of specific questions revealed the presence of several types of consistency in the responses to the two groups. They included:

1.--Consistent differences in the responses of two groups representing opposing conceptions of self;

2.--consistent similarities within each group in their responses to a variety of environmental issues; and
3.--consistencies between self-descriptions and the ways the spatial environment was construed, responded to, or manipulated.

Two studies on the influence of prior dispositions on behavior are of interest here. Gergen reports a study in which one group of subjects was led to believe that their involvement in a two-person group would be a long-term. A second group was told that it would be short-term. They found that in the "long-term" conditions subjects were significantly more self-revealing in their interactions with their partners (22). In Altman's studies with Navy personnel, he found that individual orientations influenced the spatial behaviors in dyadic groups (23). Incompatibilities on traits of need for dominance and affiliation yielded very different patterns of space useage from groups that were compatible. In the two incompatible groups, territorial behavior became quite pronounced.

In the Gergen study, expectations concerning the social environment influenced the participant's subsequent orientations to their partners. In Altman's study, characteristic orientations to others influenced the patterns of space use. Each study provides insights on the ways individuals act in the environment to support prior dispositions concerning social relationships. In the Altman study, subjects incompatible in terms of dominance and those on affiliation needs both engaged in territorial behavior. However, for the affiliation-incompatible groups this reflected social withdrawal from each other, while in the dominance situation it seemed to reflect a partial resolution of conflicting attempts to exert control by each of the two actors over one another. This occurrence of similar uses of space for very different objectives is comparable to what was found in the study reported here. Levels of use, preferences, and perceptions of the spatial environment that were similar for the two groups were found to occur for very different reasons, or to be conceived in dissimilar ways.

One way of conceiving the differences observed between the two groups may be, at the same time, both an interpretation and a hypothesis. This is to see the relation of the Inner-directed group to the environment as tending to be manipulative, and the relation of the Outer-directed group to be facilitative. That is, I.D. respondents are actively engaged in altering their contextural environment to achieve social goals, while O.D. subjects tend to act more in response to social relationships or objectives. Altman's study can be interpreted in this way also. The territorial responses of the 'affiliation-incompatible' group can be seen as a response to social withdrawal, whereas in the 'dominance incompatible' situation, establishment of territories might be characterized as "taking possession" of certain areas.

The influence that orientational dispositions have in mediating our experience of the spatial environment is also indicated in this study. The positions taken by Dubos, Condon, and McKechnie that were noted in the introduction are supported by the different, yet consistent responses of the two groups to a wide variety of questions concerning relations to the spatial environment. The results reflect Kelly's belief that "man creates his own ways of seeing (i.e. structuring) the world in which he lives; the world does not create them for him" (24).

This study was introduced by noting that it was important to recognize both the individual differences as well as the systemic regularities of behavior in studying the character of man-environment relations. By trying to stress the interrelated regularities of people's interactions with the spatial environment, and at the same time, the differences between individuals, this study attempted to identifv both individual and social factors in man-environment interactions.

This conceptual position is summed up by Snygg and Coombs who have said:

> "From the point of view of the behaver himself the causes of behavior are simple and orderly. As he himself views it, all of his own behavior is caused and reasonable. It is quite true that he does not necessarily feel this way about other's behavior.... He will even, in retrospect, regard some of his own past behavior as error,...but as he sees it at the time of action, his own acts are determined, not by chance, repetition, or habit, but by the situation in which he finds himself" (25).

Some twenty years later, Tiryakian adds:

> "...interaction with others occurs in situations that are psychologically defined by the person. That is, the site is a physical ocale of potentiality, but the situation is an actualization of the locale as a result of the meaning the person finds in it" (26).

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QUESTIONNAIRE RESULTS

QUESTION NUMBERS		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
INNER-DIRECTED GROUP	score	1.0	.36	.75	.41	3.8	3.8	.60	.48	.44	.66	.82	.73	.66	.50	.69	2.09	.54	.85	2.72	.27	(.87)	(.73)
	difference (I.D.-P)	.65	.11	.31	.24	.40	.34	.26	.21	.05	.02	.06	.04	.27	.09	.31	.14	-.01	.42	.33	.16	.13	.22
POPULATION		.35	.25	.44	.17	3.4	3.46	.34	.27	.39	.64	.76	.69	.39	.41	.38	1.95	.55	.43	2.39	.11	(.74)	(.51)
OUTER-DIRECTED GROUP	score	.15	+.08	+.10	.17	.30	.01	.13	.03	.09	.31	.16	.15	+.03	.16	+.01	.15	.15	.25	.19	.07	.15	.17
	difference (P-O.D.)	.20	.33	.54	.00	3.1	3.45	.21	.24	.30	.33	.60	.54	.42	.25	.39	1.80	.40	.18	2.20	.04	(.59)	(.34)
QUESTION DESCRIPTIONS		% who moved to a different floor of those who moved	% who moved in from other dorms	% non-spatial responses as reasons for dorm room selection	% non-positive reasons for dorm room selection	Average distance of close friends from own dorm room (1=close; 5=distant)	Average distance of acquaintances from own dorm room (1=close; 5=distant)	% who say most friends live outside own dorm	% of close friends met in unstructured social areas	% who prefer unstructured social areas to meet with friends	% of those saying the dorm is just a place to live and don't belong to organizations	% preferring each other's rooms to meet over other areas	% preferring unstructured social areas to meet with friends	% who like public-social areas best	% social values for liking dorm	% social values for disliking dorm	Point of equal similarity/dissimilarity in evaluations of others (1=dorm, 2=campus, 3=off campus)	% who say that the dorm is "just a place to live" (versus "part of it")	% giving social examples of changes in the dorm	Dorm ranking 1=average + 2=average 3= average-	% who said they had no turf boundaries, denial, etc.	% who indicate general areas as turf Note %'s are reversed	% who indicate non-personal areas as turf

TABLE 1

Divergence of Inner-Directed and Outer-Directed Groups from the Population Scores

(Population scores set to zero)

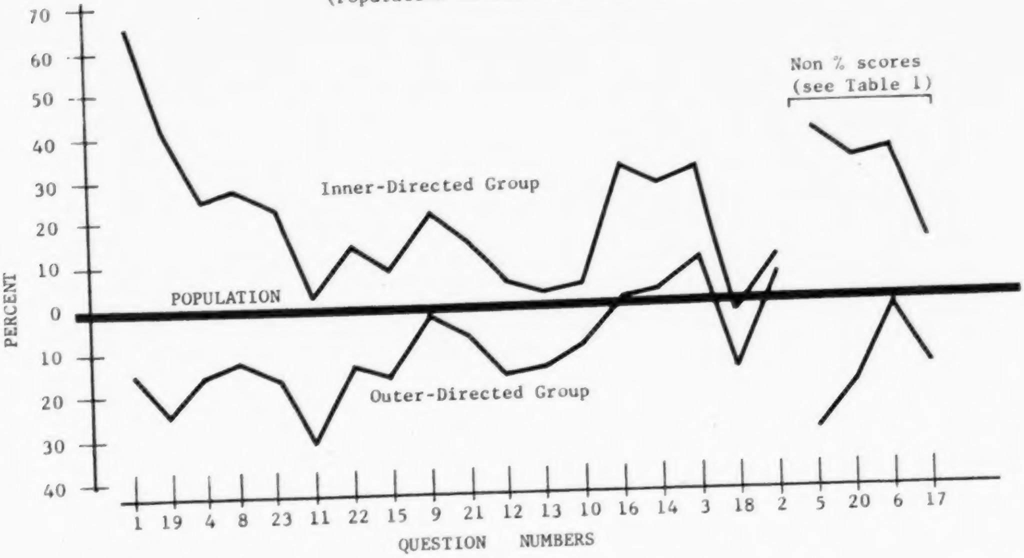
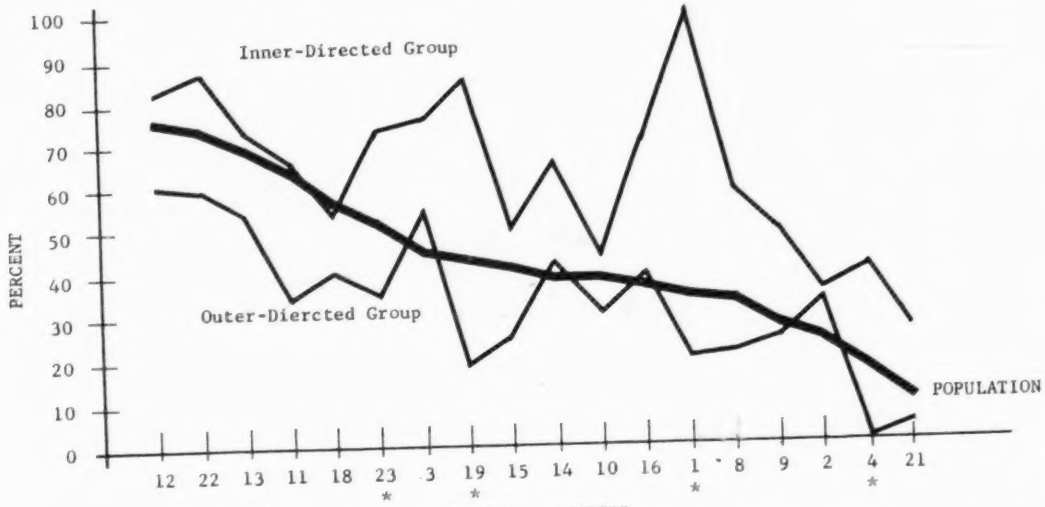


FIGURE 1

Response Percentages of the Two Groups with the Population Responses Ranked in Descending Order



(* -- indicates responses which were significantly divergent for both groups)

FIGURE 2

USING PROXEMIC INDICATORS AND INSTRUMENTS TO ANALYZE CLASSROOM INTERACTION, CURRICULUM PLANNING, AND CURRICULUM IMPLEMENTATION

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A basic assumption of this paper is that classroom interaction, curriculum planning, and curriculum implementation are affected by the physical environment. To be able to make advancements in the study of the educational process, I believe educators must be cognizant of the many factors which come into play in curriculum planning, as well as those factors influencing the effectiveness of instruction and the quality of classroom interaction.

Pursuing the notion that there are as many different ways to view curriculum and instruction as there are to analyze classroom interaction, I formulated a theoretical model of curriculum based on an interpretation of E.T. Hall's theory of proxemics. The assumption was made that an interpretation of Hall's proxemic concepts about spatial relations and interaction could be used to describe curriculum planning, curriculum implementation and classroom interaction. Using this model, curriculum planning and implementation were analyzed with regard to their structure and, in particular, to see if the components of each could be described as facilitating communication or inhibiting it. Classroom interaction was interpreted to be a response to the implementation of the curriculum.

Statement of Purpose

This paper deals with the development, findings and implications for research of two separate modes of inquiry formulated in an attempt to implement this curriculum model and to further understanding of how physical factors come into play in the classroom. The two modes of inquiry are a set of proxemic indicators and two instruments. The set of proxemic indicators, based on an interpretation of E.T. Hall's writings on proxemics, are intended to analyze verbal classroom interaction for proxemic behavior. The two instruments are used to describe the semi-fixed components of curriculum planning and implementation which control the general character of transaction and the handling of materials. The semi-fixed feature components for curriculum planning are objectives, learning opportunities, standards and optimum behavior (teacher expectations for classroom behavior) and teacher preference for room arrangement. Components of curriculum implementation include arrangement of students, materials, and furniture.

Application of Proxemic Concepts

To introduce how concepts of proxemic behavior can be used to analyze the educational process, the following discussion will be an application of the proxemic concepts of fixed-feature, semi-fixed feature (sociopetal and sociofugal) and informal spaces to curriculum and instruction. This will be done by defining the key terms in the paper.

Fixed-Feature Curricular Elements are not dealt with directly by the indicators and instruments except to acknowledge that it is the framework in which curriculum and instruction take place and includes factors over which the teacher has little control.

Semi-Fixed Curricular Elements are aspects of curriculum and instruction which can be used to control the general character of transactions and the handling of materials. This includes the teacher's unique handling of students, curriculum planning and curriculum implementation. The instruments were developed to analyze curriculum and implementation in terms of semi-fixed elements, particularly in sociopetal or sociofugal terms. Applications of these concepts to curriculum are as follows.

Sociopetal Curriculum has an emphasis on communication; use of small groups, dialogue, group problem-solving, paired learning; valuing of information flow. An objective might be to develop interpersonal skills; a learning opportunity could be a group problem-solving session. A sociopetal setting would include movable chairs placed in circles or the use of small tables.

Sociofugal Curriculum discourages interaction and may emphasize control and discipline; objectives and learning opportunities encourage the student to work alone; learning materials are not grouped to promote interaction; norms while completing assignments may include such prohibitions as no talking, no asking of peers for help, and individual completion of assignments. An objective might be to develop skills in individual study. Learning opportunities probably would have a marked emphasis on control and discipline with proscriptive norms about peer interaction. A sociofugal physical space consists of rows of desks or chairs; barriers between students; wide spaces in the seating arrangements or between speaker and listener.

Informal space is concerned with classroom interaction in proxemic terms. It is proposed that classroom interaction is a response to curriculum implementation, which is to say, the arrangement of students, materials, and furniture. Hall's scheme of four categories of informal space used to describe the types of uniform distances individuals maintain from each other can also be used to describe some types of interaction patterns found in instructional settings:

Intimate: prohibited except under specified conditions such as warm, nurturant preschool teacher.

Personal: teacher-student conferences, paired-learning, tutoring.

Social: group problem-solving, seminar, some American public school classrooms.

Public: large lecture sessions.

To reiterate, application of this curriculum model and inquiry into systematic relationships in classroom interaction, curriculum planning and implementation pointed to this specific problem:

(1) to formulate and evaluate proxemic indicators to classify verbal proxemic behavior from classroom interaction, and

(2) to construct two instruments to describe the semi-fixed aspects of a curriculum (planning and implementation) in sociopetal and sociofugal terms.

Theoretical Background

The primary theoretical source for the development of the indicators and instruments were writings by E.T. Hall and H. Osmond. Proxemics is the study of human perception, structuring, and use of space (1). The anthropological model of space conceptualized by Hall deals with proxemics or man's use of space. Hall (2) proposed that proxemics can be understood only in terms of a multilevel analysis of its manifestations and related determinants. The three levels are infracultural, precultural, and microcultural . The focus of the instruments and indicators is the microcultural level. The three aspects of proxemic manifestations at this level are fixed-feature, semi-fixed feature and informal.

Hall (3) discussed fixed-feature space as being one of the basic ways of organizing the activities of individuals and groups and includes material manifestations and hidden internalized designs. For our purposes, it is assumed to be the framework of the behavior observed in semi-fixed feature and informal space situations.

Semi-fixed elements enable man to increase or decrease his rate of interaction with others and to control the general character of his transactions (4). Also included are how and where belongings are arranged and stored. Again, the critical concern for this discussion is Hall's assertion that the structuring of semi-fixed elements can have a profound effect on behavior and that this effect is measurable (3). The indicators and instruments are primarily concerned with sociofugal and sociopetal types of semi-fixed feature spaces.

Osmond (5), a psychiatrist, believed that there are some qualities of buildings which can be called sociofugality and sociopetality. He defined sociofugality as a design which prevents or discourages the formation of stable human relationships. His examples of sociofugal structures include railroad stations, hotels, and jails, to name a few. Sociopetality, on the other hand, encourages, fosters and enforces the development of stable interpersonal relationships such as are found in small face-to-face groups. Osmond described the tepee and igloo as being highly sociopetal.

Informal space includes the distances maintained by individuals in encounters with others (3). Hall stated to know man, one must know something about the nature of his receptor systems and how the information received is modified by culture. This is proxemic analysis at the precultural level. According to Hall, one must refer to the precultural sensory base to compare proxemic patterns. Each sense modality plays a part in the perception of space (6). The development of indicators dealt with the precultural level in reference to sense modalities.

Hall (3) proposed that informal space consists of a series of uniform distances which individuals maintain from each other. He felt that the meaning and use of distance is a significant cultural factor in interpersonal relations. These distances are mostly out-of-awareness and unstated. The regularity of distances observed for human beings is the consequence of sensory shifts. Hall (3) developed a scheme of four distances with close and far phases: intimate, personal, social and public, to provide clues to the types of activities and relationships associated with each distance. These categories were based on observations and interviews with non-contact, middle-class, healthy adults, mainly natives of the northeastern seaboard of the United States.

To summarize, after reviewing the available literature on proxemic behavior and the influence of space and spatial relationships upon human behavior, two modes of inquiry were developed from an interpretation of this literature, and, in particular, from the writings of Hall and Osmond. The proxemic indicators which were developed during this study used Hall's notions of informal space and are defined as verbal references to sensory data concerning man's perception of interpersonal space or distance. Hall (7) defined interpersonal distance as a constellation of sensory inputs coded in a particular way. The various distances are the consequences of sensory shifts (3). Unselfconscious comments, made as a result of some breach of spatial etiquette are cited as a source of data (7). Using this rationale, proxemic indicators were developed to analyze verbal behavior for proxemic content.

For the purpose of inquiry into curriculum planning and implementation, the concepts of sociofugality and sociopetality were extended from the original notion of describing the communication function of physical structures to describing the communication function of actual classroom curriculum plans and actual implementation of the curriculum defined as the arrangement of students, materials and furniture.

Development of Proxemic Indicators

In the discussion which follows, I will briefly sketch the notions underlying the development of the proxemic indicators. Hall (3) maintained that to understand man, something must be known about his receptor systems (senses) and how the information received is modified by culture. He distinguished two groups of receptors: immediate and distance. The immediate receptors are used to examine the world close up: touch, kinesthetic involvement and sensations of heat and of the skin. Distance receptors are used to examine distant objects and include the eyes, ears, and nose.

It occurred to me that these two types of receptors could be coordinated with Osmond's concepts of sociofugality and sociopetality. Sociopetal settings promote interaction therefore logically suggesting the interplay of the immediate senses; whereas sociofugal settings inhibit or prevent interaction thereby suggesting a reliance on the distance receptors. Hall's categories of informal space (intimate, personal and social-close), which primarily use the immediate receptors, were coordinated with sociopetal space; (social-far and public), which use distance receptors, were coordinated with sociofugal space.

In other words, the distances of intimate, personal and social-close rely on the immediate receptors in encounters with others--tactile, thermal, kinesthetic and some aspects of oral/auditory (whispering, conventional modified, casual or consultive) senses. It is proposed that interaction characterized by immediate face-to-face interaction would be in a sociopetal setting.

Likewise, social-far and public-close distances are more dependent on the distance receptors or the visual, auditory (up to 20') and olfactory senses (3). Since social-far is characterized as having interaction of a formal character which can be used to screen or insulate people from each other, and public distance as being outside the area of involvement (3), these two distances are described as being sociofugal.

A classification of proxemic indicators was developed using this rationale. It presented the observer with possible descriptions, comments and examples (most gleaned from Hall) of a person responding in terms of his senses to a specific spatial arrangement. For example, if we looked at part one of the classification scheme, which was devoted to receptors using the immediate senses in sociopetal spaces, the indicator corresponding to tactile sensory space reads as follows:

Sensory space	Indicator Classification
tactile	Statements about texture; crowds, crowding, jostling, feelings about being touched (by strangers); changes in texture (3).

This classification of proxemic indicators was intended as a guide for the observer to analyze classroom interaction for verbal proxemic behavior. The scheme is assuming that sensory spaces and communication arrangements fit together. An informal hypothesis might be that a person relying on his immediate senses would be within an intimate, personal or social-close distance and in a sociopetal arrangement. Before discussing the application and evaluation of these indicators in an experimental session, there will be a discussion of the two instruments developed to describe curriculum planning and implementation in proxemic terms.

Development of Instruments

The basic assumption in the development of the two instruments was that curriculum and its implementation can be analyzed in terms of semi-fixed features and, in particular, sociopetal and sociofugal characteristics. Instrument 1 is a two-part questionnaire which is to be completed by the teacher. Part one is made up of sections with items concerning objectives, learning opportunities and standards for interpersonal interaction. The questionnaire is a type of summated rating scale. Each item has a response with five degrees of intensity. The respondent selects a response for the appropriate degree of intensity. Each degree of intensity is weighted so that sociofugal scores are low and sociopetal scores are high.

Part two of Instrument 1 was an adaptation from the Teaching and Learning Preference Questionnaire designed by Feitler, Weiner and Blumberg (8). The purpose of their study was to examine the relationship between interpersonal needs and the physical setting of the classroom. The subject was presented with seven classroom arrangements and was asked to rank them as to which would be the most comfortable for them while in the role of teacher. Considering this study, it appeared to me that the classroom arrangements which Feitler et al. used in their experiment were good examples of sociopetal and sociofugal spaces. Accordingly, I reinterpreted some of their results with reference to sociopetal and sociofugal spaces and informally hypothesized a relationship between control needs and the selection of sociopetal or sociofugal arrangements. The results from the Feitler et al. study showed that the arrangements which persons with high control needs chose as most comfortable were sociofugal. Whether the respondent realized it or not, these arrangements were designed to control or limit interaction. Further, persons with low control needs primarily chose sociopetal arrangements. This is consistent with the observation that sociopetal arrangements encourage interaction, thereby allowing for more flexible situations. An adaptation of the Feitler et al. questionnaire was included because it is a graphic way for the respondent to give his preference for a classroom arrangement for the particular curriculum under consideration. The teacher is asked to select and rank the two classroom arrangements which he most prefers and least prefers for his particular curriculum. Each arrangement in the questionnaire is designated as sociopetal or sociofugal.

Instrument 2 is an observer report and was completely revised during the study. It is composed of five sections: arrangement of materials; arrangement of students during activities; arrangement of furniture; chart of room; and a section for teacher comments about room arrangement, learning materials or positions of teacher or students. Each item was designated as having a sociopetal or sociofugal orientation and is coded accordingly.

Collection of Data

Data were collected from a video tape event sample; from the completion of Instrument 1 by two university instructors; and the completion of Instrument 2 by the researcher. A ninety-minute video tape event sample was made during a class session of one instructor. It was assumed that the gathering of data in an event sample by using a video system was acceptable as Hall (3) explained the distance-sensing process to be primarily out-of-awareness. Therefore deliberate distortion of proxemic behavior by the subjects was unlikely.

Treatment of Data

A co-rater and I used the indicators to analyze the video tape event sample. The unit of analysis was an episode, could range from one word to a statement and was indicated by a change in speaker. The ninety-minute tape was divided into five-minute segments. Each rater coded episodes as being proxemic or non-proxemic on identical tally sheets. Under the column for proxemic episodes, the rater would mark whether the episode was characterized as using an immediate receptor (tactile, thermal, kinesthetic, oral/auditory or visual) or a distance receptor (visual or oral/auditory). In other words, each episode which occurred in any five-minute segment was recorded under the appropriate sensory category.

During a preliminary analysis of a twenty-minute sample, specific problems were observed by the rater and researcher: (1) discriminating between the concrete and the abstract use of sensory-based verbal behavior; (2) coding only verbal behavior when physical proxemic gestures were also made; (3) coding each episode only once even when it was embedded into a non-proxemic episode; (4) determining appropriate verbal expression of emotional states as proposed by the criteria in the indicators; and (5) confusion in discriminating between thermal and kinesthetic verbal behavior because the indicators were unclear.

The primary difficulty centered around the concrete versus abstract use of sensory-based verbalizations. Concrete verbal behavior was defined as referring explicitly to an incident in the present situation. In other words, for proxemic behavior to be recorded, it had to be a result of the present physical situation either between persons, or between a person and an object or structure.

Abstract proxemic verbal behavior would be concerned with present, past or future situations; internal emotional states; or descriptive word usage, all of which are not a result of the present physical situation. An example of an abstract present situation, not in the immediate classroom but which had a sensory base, would be: "A school is looking for volunteers (visual-distant)". An abstract internal emotional state might be: "I have known people who picked up anxiety...(kinesthetic-immediate)." Abstract descriptive usages might include "carrying a burden" (kinesthetic-immediate) or "...family with warmth and security" (thermal-immediate).

As a result of rating difficulties, coding of proxemic verbal behavior was limited to specific classroom incidents excluding any sensory-based verbalizations in the abstract as defined above. Only concrete proxemic behaviors which could be behaviorized were recorded. To facilitate the coding of episodes, when a proxemic verbalization was made, it was coded separately even if it was embedded in a non-proxemic episode.

The classification of proxemic indicators was specifically designed to code verbal behavior and to exclude gestures. This was difficult to do as the co-rater and I frequently "read" the gesture as if it had been spoken. For example, one student in the video tape event sample twisted her body around (kinesthetic-immediate) to talk to someone near her, and as she spun around she clasped hands with him (tactile-immediate). The indicators were expanded to include gestures.

As discussed previously, two university professors completed Instrument 1 and the researcher completed Instrument 2 during a class session of each instructor. The purpose of scoring was to define the orientation of the curriculum plans and implementation with reference to sociopetal and sociofugal types. The treatment of data from Instruments 1 and 2 was primarily a type of content analysis. Rather than computing only one score from the total combined items, the scores were grouped into clusters to look for relationships among the components. For example, a comparison could be made of the objectives component and of the learning experiences component to determine if they are complementary, that is, have the same orientation, or if they are incongruent.

A percentage score was computed for each component. Percentage scores of 0-49% were designated as sociofugal; 51-100%, sociopetal. When percentages fall at 50%, they were considered to be neutral or non-discriminating. The mean percentage computed indicated the over-all orientation of the components.

Cluster percentage scores for Instrument 1 were computed for each component: objectives, learning opportunities, standards, problems, optimum behavior and teacher preference for room arrangement. Likewise, Instrument 2 was broken down into arrangement of materials, arrangement of students, arrangement of furniture, chart of room and room change (if applicable).

Findings from Analysis of Event Sample

As previously discussed, the video tape event sample was analyzed by a co-rater and researcher using the classification of proxemic indicators. In presenting the findings of the analysis, the frequency distribution of recorded proxemic episodes can be discussed in relation to data collected by Instrument 2 as this data describe the instructional setting.

Considering first the frequency distribution of immediate proxemic episodes, it was apparent that very little proxemic behavior reflected tactile, thermal or kinesthetic concerns. More episodes were recorded in the oral/auditory-immediate category. This category contained verbalizations about voice volume, particularly that which is too loud. However, it was expanded to include comments about casual or consultive conversation. For example, questions or clarifications from one individual to another could be included: "What are you saying?"; "You are talking about...."; "I am not making myself clear."; "I wanted to say ...."

No episodes were recorded under visual-immediate category for expressions of visual distortion and/or discomfort because of extreme closeness to another person or object. That no episodes were recorded is consistent with a diagram in Instrument 2 of the room arrangement showing the diameter of the circle to be over seven feet.

A greater incidence of episodes was recorded in the distance category of receptors than in the immediate category. This lends support to the assumption that proxemic behavior was a response to the physical setting, in this case, a rather large circle with a diameter greater than the distance for personal or social-close conversation. Although a circle is designated as being sociopetal, when the diameter is greater than seven feet, interaction appears to be limited or strained. This is evidenced by the higher incidence of proxemic episodes in the visual-distance and oral/auditory-distance categories. Because of the large size of the circle and double rows along the rear, visual contact and hearing were limited, thus individuals in the class setting were mostly dependent upon the visual-distance and oral/auditory-distance senses for information. Episodes in the visual-distance category included questions such as "Who are you?" but more frequently consisted of one individual indicating to another or pointing across the circle. Oral/auditory episodes were mostly incidents of students saying "pardon" or "What did you say?".

Findings from Analyses of Instruments

The specific findings from the analyses of instruments for each instructor will not be presented. Rather a brief description of the treatment of the data and a discussion of the findings as a whole will follow.

A co-rater and researcher scored the instruments and determined the orientation of the components in terms of percentages. The instructors were asked to answer Instrument 1 as being representative of the course as a whole, not for the particular lecture or group session observed. Within Instrument 1, the component percentages were compared for discrepancies and consistencies in their sociopetal or sociofugal orientations. Within a component showing discrepancies, items were analyzed to determine if the items were a source of confusion for the respondent and thus the possibility that the responses reflected unclear items rather than an accurate assessment of the situation by the instructor. Difficulties with the wording of the items were taken into consideration. For example, one instructor was unable to complete any items which used the word "required" because he had no set course requirements.

Likewise, a content analysis was made of the data from Instrument 2. Even though Instrument 2 was formalized in the process of observing the class sessions, data were collected and analyzed uniformly for both instructors. Additional modifications were made after an evaluation of the instrument. Items were added to describe situations that had not been considered previously. Most revisions and additions were to make the instrument more sensitive in describing the learning situations.

In general, an evaluation of the findings showed that a content analysis of the curriculum plans and implementation strategies was possible from the data provided by the instruments. One can determine the over-all orientation of the plans and implementation strategies as well as to pin-point discrepant components. In some instances the inconsistencies in orientation were apparent within the curriculum plans. For example, Instructor A's preferences for arrangement, expectations for optimum behavior, and view of class problems were sociopetal, yet his objectives were sociofugal and his plans for learning opportunities had no specific orientation. Clearly, inconsistencies of this sort could be confusing to the learner.

Likewise, one can compare the relationship between the orientation of the curriculum plans and the orientation of the implementation strategies of these plans. An analysis of the findings from Instruments 1 and 2 for Instructor B's lecture sessions suggested a consistent relationship. The room was a large lecture hall of an extreme sociofugal type with fixed desks mounted on a graded plane. For the most part, a speaker at the instructor's desk would be at a public distance. Whether the instructor tailored his curriculum to fit the room was not apparent; however, it can be inferred from his comments about class size and the room that he was aware of the physical limitations and this did affect his curricular decisions. For example, learning opportunities which required discussion among class members were not selected to be used in this particular physical situation. When group assignments were made, they were carried out elsewhere.

Because of the complexity of Instructor B's curriculum, he was asked to complete Instrument 1 twice for his course. One questionnaire was devoted to the lecture sessions as a whole; one, to the small group sessions as a whole. Instrument 2 was also completed twice, once for each situation. By having two completed questionnaires from Instructor B, it was possible to inquire into intra-curricular differences or to see if the instructor varied his objectives, learning opportunities, standards and expectations for different curricular situations. The analysis of findings for Instructor B supported the possibility of this type of comparison. Instructor B's plans differed in regard to lecture and small group sessions. Moreover, it appeared that the lecture sessions were influenced by the physical structure of the room, but there was less awareness of the influence of the physical structure in the small group sessions room with movable furniture. The physical structure may be more obvious if it is limiting, while the facilitating possibilities may go unnoticed.

Validity and Reliability

Before discussing the conclusions and implications for research, the topics of validity and reliability should be considered. The methods for ascertaining validity were those of content validity based on a logical analysis of readings on proxemics and criterion-related validity. The data from the analysis of the event sample can be considered to be a direct measure of the items in Instrument 2. Instrument 2 is a second source of information about teacher behavior besides Instrument 1 (teacher questionnaire).

Reliability was estimated by the percentage of agreement between a co-rater and researcher on the occurrence and classification of proxemic behavior in a video tape event sample; on the computation of the instructors' summed component scores; and on the determination of the orientation of the various components in the two instruments as being either sociopetal or sociofugal. The percentage of agreement between the co-rater and researcher on the analysis of the event sample indicated it was possible to obtain a positive percentage of agreement despite lack of previous experience on the part of both the rater and researcher in coding proxemic episodes.

The computed estimates of reliability for the instruments were extremely high. Two qualifications should be made with reference to the estimates of reliability on the instruments. First, 100% agreement should be expected as scoring of the instruments was computational. Strictly, speaking, the agreement was on computing correctly the same percentage score. The uniform scoring procedure is explicit and only the topics of mixed seating, chart of room and teacher comments require any additional knowledge of sociopetal or sociofugal situations. For these topics, a second qualification is needed. Because I acted as the observer, I interpreted to the co-rater class notes, drawings of room arrangements, and answered questions about responses on Instrument 2. Because of this source of bias, the reliability estimates should only be considered as an indication that the instruments can be scored uniformly and that the concepts of sociofugality and sociopetality can be applied. This same consideration should be made with regard to the proxemic indicators. In summary, the reliability estimates indicate the applicability of the instruments and indicators in analyzing curriculum planning and implementation for proxemic behavior. Also illustrated is the necessity for more extensive training of the co-rater if he is to work independently from the researcher.

Conclusions

It was concluded from the findings that the proxemic indicators can be used to analyze classroom interaction for proxemic behavior and that the two instruments adequately describe the semi-fixed aspects of the curriculum (planning and implementation) in proxemic terms. Although the proxemic indicators were developed to be used independently from the instruments, it was demonstrated that these two modes of analysis can be used in conjunction with each other.

Methodologically, the indicators and instruments provide another means of analyzing classroom interaction and of viewing curriculum planning and implementation. It is also possible to compare different curriculum planning and implementation styles of an instructor in different physical settings.

The indicators and instruments offer fruitful possibilities for theoretical study of classroom interaction and curriculum development. For example, the findings in the present study illustrated that classroom interaction can be analyzed for proxemic behavior; therefore, inferences can be made about proxemic behavior in the classroom and of appropriate ways to set up the classroom in proxemic terms for a more effective instructional process. The two instruments may offer insight into curriculum plans and implementation styles as they can be analyzed as components and compared with regard to their orientation toward facilitating or limiting communication. Because of this, the degree of congruency between plans and implementation can be determined. Further, the proxemic indicators can be used in conjunction with the instruments to determine if incongruency between the plans and implementation strategy manifests itself in classroom interaction.

It seems reasonable to me to propose that these indicators and instruments have a practical value in understanding one aspect--the proxemic aspect--of the educational process in that they offer another source of information about some factors which make for an effective instructional process. Further, intra-curricular incongruencies can be detected and alternative means to implement the curriculum can be specified.

Implications for Research

An important implication of the findings was that the indicators and instruments should be modified to increase their applicability and effectiveness. Subsequently, revisions and modifications were made.

Modifications of the proxemic indicators centered upon specific difficulties encountered by the co-rater and researcher during the analysis of the video tape event sample. As discussed previously, these weaknesses included: manner of presentation of the classification of proxemic indicators which did not allow for quick reference while coding; sensory categories which seemed to duplicate each other; and unclear indicators which made discriminating among sensory categories difficult. A revised classification of indicators was constructed to alleviate some of these difficulties. Other specific difficulties included: distinguishing between speakers in order to code speaker changes; recording episodes when two or more speakers were talking at one time; and recording speaker changes when one speaker was talking and another speaker interjected a comment in the middle of the episode. Two ways to counteract these difficulties are (1) use of more room microphones and (2) more extensive training of persons recording behavior.

Needed revisions in Instrument 1 were apparent after an evaluation of the instructors' responses and comments. Some of the revisions in Instrument 1 are as follows: changing of the instructions to include a "not applicable" response; clarification of items which did not discriminate successfully between sociopetal and sociofugal orientations and a space for instructor comments after each item.

Revisions in Instrument 2 were made so that items might discriminate more clearly between sociopetal and sociofugal situations and so that items were included for other possible situations. For example, one item (grouped resources consolidated into centers) was intended to describe grouped resources such as interest centers, learning centers, book tables, et cetera, which, by virtue of being grouped, would tend to increase communication among participating students. However, this item did not anticipate grouped materials for the teacher's use or materials located near the teacher and thereby discouraging participation. Therefore, another item was added for this possibility.

The revised indicators and instruments have not been used thus effectively evaluated; however, since the revisions were based upon observed weaknesses, it is probable to assume an increase in effectiveness. Follow-up studies would determine if reliability estimates were increased and initial problems minimized or eliminated. If video equipment is not available for a classroom observation study, two raters can be used to record proxemic behavior simultaneously during a regular class session. However, it should be pointed out that a video tape event sample has certain advantages: analysis can take place out of the interaction context with its sources of distraction; video systems allow for replay; and most importantly, it allows for various raters to analyze the tape.

It is proposed that curriculum construction and implementation is a complex endeavor which must take into consideration varied concerns. The instructor should understand the effect of his arrangement of students, materials, and furniture upon the implementation of his curriculum plans. He should be aware of the need to maintain internal consistency within his curriculum plans as well as consistency with his implementation strategies. The indicators and instruments were constructed to provide a method of analysis for these purposes.

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3: BEHAVIOR IN COMPLEX ENVIRONMENTS

GROSS SPATIAL MOTION OF A SOCIAL GROUP WITHIN A COMPLEX ENVIRONMENT (1)

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The Social N-Body Problem

In the history of science, discoveries and breakthroughs in understanding have often followed the development of a new instrument or methodology which permits the study of phenomena previously inaccessable because of scale or complexity. One kind of complexity, common in both the physical and social sciences, occurs in the treatment of several entities interacting simultaneously. When studying interacting particles, for instance, physicists find a disproportionate increase in the difficulty of both expressing and solving a problem as the number of particles, N, increases. Thus situations with many participating entities are categorically designated as N-body problems.

At the Laboratory of Brain Evolution and Behavior of the National Institute of Mental Health we have developed a system which significantly expands the capability for studying the social N-body problem. This problem has suffered from theoretical and experimental difficulties of greater magnitude than even those encountered in physics. These difficulties occur in the study of social groups of a few to many animals where the identification of each animal is crucial, or where the group is not large enough to be amenable to a statistical approach. For example, the growth of the human population leads to an interest in the behavior of individuals under crowded conditions. In research with animals behavioral changes and related physiological processes have been observed to accompany decreases in the growth rate of confined populations. Rodent populations exposed to conditions which should encourage high density, for example, demonstrate such self-limitation (2). It is of great interest to understand the mechanism of this process, particularly in reference to accompanying changes in the patterns of social interaction in the group.

Up to now, the study of the dynamics of social interactions within large confined groups has been severely hampered by the lack of detail available in observational data. Visual observations of even a small group of moving animals over more than a brief period of time is difficult and the resulting data will be incomplete. In the conditions of high density associated with the self-limiting process accurate and complete visual data collection becomes impossible. Since the physical structure of the environment is itself a determinant in the process of population growth and the stability of the social system, it is also desirable to monitor behaviors occurring in and constrained by a structured space of variable complexity.

Formulating the Monitoring Problem

A methodology adequate for the study of the class of social problem indicated above must be capable of recording subsets of the behaviors of each member of a group of N animals within a bounded environment E over an interval of time T. Typical values for an experiment on the growth of a rodent population are $N \sim 10-1000$, $E \sim 25$ square feet, and $T \sim 1-3$ years. With these parameters a tremendous amount of data can exist, of which only a minute fraction can be sampled (and then only unreliably) by visual observations. Photography can be used but only postpones the problem of data identification. The many possible schemes of automating the data collection all involve a systematic reduction of the data during collection, either by the class of behaviors observed, or by the frequency of sampling, or both. One can, however, structure the environment so that easily monitored behaviors believed to be socially significant will occur.

Both of these approaches are incorporated in the experiment described below, where we are tracing the paths of a group of fourteen rats in a bounded, artificial environment. The animals are monitored when passing from one subspace of the environment to another through portals. These portals identify the animals and determine direction of passage. We will discuss the details of this system after considering the kinds of data it provides and formulating a model for the behavior of the system. This model is based on results from previous studies, and leads to several hypotheses which the monitoring system is capable of testing.

The Model and Experimental Hypotheses

Spatial Motion and Social Structure

Relationships between spatial behavior and social structure have been observed in many species of animals. We will consider spatial behavior to be the motion of the animal over some distance large compared to its body size. This simplification, intended to ignore other significant communication channels such as body orientation, movement of the body surface and motions localized in a small area, is equivalent to treating each animal as a point particle (3). Social structure will be taken to be the existence of predictability in the interactions between animals (4). In the structure known as the dominance hierarchy, for instance, we observe that certain two animal (dyadic) interactions which are unsymmetrical (such as fighting) occur with a degree of predictability sufficient to establish an ordering relation among the animals. The concept of territory explicitly expresses a relationship between motion and structure. This well known concept is derived from the observation that the localization of the motion of an animal within a portion of the environment is correlated with his defending this subspace, by threatening and/or fighting. Moreover, usually he prevails over an invader, that is, a second animal whose motion was previously not localized within this subspace. The territorial mechanism creates a system of overlapping subspaces each occupied by a social unit, e.g., a single male with females or young. In larger groups, which may share a defended group territory, structural mechanisms may emerge within the group itself. If such structure exists it may be exhibited in the spatial behavior of the individual animals. An important question is whether the motion of the animals contains sufficient information for an observer to determine the social structure. The positing of this question in fact is the central hypothesis of our current experiment, and the primary motivation behind the development of the experimental apparatus:

> The totality of motions of single animals in an interacting group is capable of predicting regularities in the dyadic interactions within the group and thereby determine its social structure.

Some additional ideas needed in our model and the exploration of this hypothesis will now be developed.

The Social Velocity Hypothesis

To investigate the motion of members of a social group, we view the group as a system of point particles. The motion of the totality of particles will then simply reflect the relationship between pairs of particles. (The motion of the planets in the solar system, for example, reflects the law of gravitational attraction between pairs of masses) (5). If the particles are relatively motionless, we can describe the group in terms of the deployment of the members. Thus the static case corresponds to the territorial model, where space is differentiated in some way and an animal's status will depend on the largeness or proximity to resources of the territory he defends. The occasional interactions of adjacent animals could result in some kind of ordering relationship.

When, however, animals interact frequently within the same space they move relative to one another. Thus our model becomes kinematic and requires the concept of "social velocity". In physics, the velocity of a particle is a vector whose three spatial components reflect the instantaneous time-rate-of-change of the particle's position. The application of this idea to the social order will of course not be unique; below we enumerate the simplist possibilities.

1. If during some time interval t animal i covers a distance s, then a velocity is described as $v_i = s/t$. This is simply the average speed of an individual animal.
2. If an animal interacts with m other animals (where the interaction may be defined as merely being in the same subspace of the environment), then the velocity is just $v_i' = c'm/t$, where c' is a scaling constant used for relative normalization.
3. If an animal trarsverses k subspaces, such that d_j, $j = 1,2,\ldots,k$ is the size of the j'th subspace, and w_j is the weight of that subspace, then $v_i'' = (c''/t)\ \Sigma w_j d_j$. The weights w_j could be derived, for example, from the resources in subspace j, the number of animals in subspace j simultaneously with animal i, or the number of paths crossing subspace j.
4. One could modify v_i' to recognize the relative status of the animals which are encountered, or perhaps their sex: $v_i''' = (c'''/t)\ \Sigma R_p$, where R_p is the status of animal p, $p = 1,2,\ldots,m$.
5. A further velocity might be defined, v'''', which gives the frequency of entering (or equivalently changing) subspaces.

For the purpose of relating social velocity to social structure, it should be noted that v, v'', and v'''' depend soley on the motion of the animals, whereas the other two velocities require some knowledge of relative status. Consequently we will consider only the three status independent velocities, and will generalize this set by the symbol v. With this definition in mind, we now formulate several specific hypotheses:

1. The rank of the animals in a dominance hierarchy is a function of their social velocity, v. (For instance, it is possible that the animal with the highest rank, as determined, say, from visual observations of fighting, will have the highest social velocity.) This hypothesis constitutes the original use of the term "social velocity" in this context, and was proposed by Calhoun when analyzing mechanisms involved in optimum group size (6).

2. The form of the distribution of velocity with rank is a measure of the social health of the group. That is, the function above reflects the appropriateness of the size of the group both for its environment and in relation to the optimum intrinsic group size for that species. This is, briefly, the link hypothesized by Calhoun (7).

3. The degree of conformity with the normal diurnal rhythm reflects social rank. This hypothesis is derived from observations of wild rats in a semi-natural environment (8). Rats normally have a bimodal activity distribution where activity is highest at dawn and dusk. Calhoun observed that the activity of lower status animals was shifted off of this pattern, to earlier and later times. In order to determine the conformity of the data with this hypothesis, we must determine the social velocity for each animal as a function of the time of day.

4. Animals of high status exhibit greater predictability in their use of paths and rarely reverse direction during movement along these paths.

These four hypotheses may be tested with the data obtained from our monitoring system and compared with social structure derived from visual observations, such as the dominance hierarchy determined from observations of fighting.

The Sensitivity Hypothesis

Many social interactions take the form of motion by the animals individually, with respect to one another, or as a pair (e.g., chasing, avoidance). In fact a model of interaction by avoidance is supported by the observation of withdrawal, where animals of low status limit their motions to essential resource utilization. In a more general model, a lower status animal will avoid the space-time behavior combinations "occupied" by animals with higher status. The higher status animal could thus be said to be "free" to move wherever he chooses. Although our intentions include validating these links between specific aspects of motion and social structure, a more general purpose is to discover whether the data obtained from our automated monitoring system is a sufficiently sensitive measure of the social system at a given point in time. In other words does the data contain information which is equivalent to the social structure, and if so, how sensitive are the analytic results to change in the structure. If they are very sensitive then one could, say, observe the distribution of velocity with rank, the distribution of activity over the 24 hour day, and perhaps the frequencies of paired association while the social system and/or its environment was being manipulated in some way. The results derived from motion alone could then reflect small changes or instabilities in the structure, which might otherwise require extensive visual observations. To support this possibility we now provide a more detailed description of our monitoring system.

The Data Acquisition System

In the discussion of the general monitoring problem above, it was suggested that the environment might be structured so as to encourage certain easily monitored behaviors. One such approach is to confine the animals to move in tunnels. If the tunnels then permit only one animal in a given length at any time, photoelectric cells could be used to detect motion along each tunnel. If a network of such tunnels were constructed, and resources placed in spaces at the end of them, then the motions of one or a few animals from one resource to another could be measured. This approach has in fact been used for studying the sequences among a small set of resource utilizing behaviors, but it restricts freedom of motion, and cannot distinguish between individual animals (9).

The opposite approach, namely, allowing freedom of motion within a bounded, three-dimensional environment, has also been used (10). Generally the subjects are fitted with either a passive or active radio transmitter. In the former case, the transmitter sends an identifying signal only upon interrogation from the detection system, whereas an active transmitter sends out some distinguishable signal at regular intervals. The location of the transmitter is determined by triangulation, that is, by measuring the distance of the transmitter to two or more points using the amplitude or phase information in the signal. The use of individual transmitters has many advantages, including greater freedom for the subjects. The precision of the locating signal is dependent on its frequency, and for some applications localization within the nearest acre is satisfactory. However, for monitoring the social interactions of a large number of animals confined to a small area, far greater precision is required. In fact, ideally one would like to locate the animal with a precision equal to one animal diameter. The transmitter (or "reflector" if it is passive) should also be small enough so as not to restrict the animals motion, and in fact be undetectable by the animal in its normal postures (11).

Our system, developed by the Technical Development Section, NIMH, and the Biomedical Engineering and Instrumentation Branch, NIH, represents a potentially powerful combination of the tunnel and the freely moving detector techniques cited above. The environment of the animals (laboratory rats) is divided into 17 "zones" by various types of barriers (Figure 1). Each zone contains a different resource, such as food pellets, a water source, open space, or a shelf of nesting boxes. The animals are free to move at will within these zones. However, to pass from one to another, they must move through a detector-portal. This is a short tunnel whose wall is made up of concentric electromagnetic drive and detector coils. Each animal is implanted (beneath the skin in the abdominal region) with a glass-enclosed passive resonator circuit, which is excited into oscillation at a unique frequency by the pulsed field of the drive coil. Twin detector coils measure the frequency, and using the sequence of detection, determine the direction of the animal in passage. The portal then relays the frequency and passage direction data to a small computer, a Varian 620/i. The portal electronics is designed so as to respond only to a complete passage, so that a rat coming only part way in and then withdrawing is not counted. The nineteen portals currently used in the experiment are connected in parallel to the computer through a scanning device which allows storage of passage data from several portals simultaneously. When the central processor is free, the passage data is associated with the particular portal from which it came and with the time of the event derived from a real time clock. This event is then recorded in sequence on magnetic tape.

In addition to processing the data from the nineteen portals, the system is also capable of accepting data on lever press events. Coded behavioral data from visual observations is entered manually on a keyboard. This information is automatically placed in sequence on the tape with the passage data from the same animals and permits a significant reduction in the information which the observer must record for each behavior. Another possible feature is to allow the computer to turn on a video tape above the room when a certain group of animals is beneath it, say, in the center area.

This system has been developed during the past five years. It was first used to collect data in October, 1971. There are several possible limitations of this monitoring system. These result largely from the fact that the system approximates the continuous motion of the animals by monitoring their transitions between subspaces. The meaningfulness of the data and in fact the disturbance introduced by the system is thus strongly related to the fidelity with which the space is divided into appropriate behavioral settings. Secondly, the portals themselves elicit certain behaviors which are essentially elaborations of passing through them--hesitations, looking through, defense of the portal as a passage between points, etc.

Pilot Studies Using the System

The first use of this system was a pilot study intended to test the system under future conditions with a group of implanted animals. In October, 1970, 35 domesticated laboratory rats (Osborne-Mendel Pen-Bred Strain) were implanted and placed in isolation. In December, a prototype of the environment pictured in Figure 1 was constructed, and twelve male and twelve female rats were selected on the basis of the non-overlap of their implant frequencies. This group of 24 animals was placed in the pen in January, 1971.

Criteria for the Design of the Environment

In designing the environment to be used in the pilot study, several constraints impinged on the goal of providing a "natural" environment for the animals. The design of this environment has, in fact, proved to be a challenging part of the ongoing experiment. The laboratory building in Poolesville, Maryland in which this study is being conducted contains sixteen identical experimental rooms, each providing a minimum environment for a group of rats. The environment of the animals for this experiment is a development of this basic room design, which consists of a 9x9x12 foot room, with four rows of nest boxes on each side wall connected to the floor by a system of ramps. The rationale of the monitoring system requires the placing of important resources (e.g., food and water) in separate subspaces, so that motion measurable by the system is constrained to occur. The nest shelves already existing in the room, a food box, and the water dispensing apparatus (STAW) were thus allocated to separate subspaces. We also provided a "social interaction" or confrontation zone observable from above, which the animals (at least part of the time) would enter on paths to resources. In addition, to support future studies of interacting groups, the room was made bilaterally symmetrical. These criteria were the rationale for the basic configuration of the experimental environment. The design of the remaining features followed

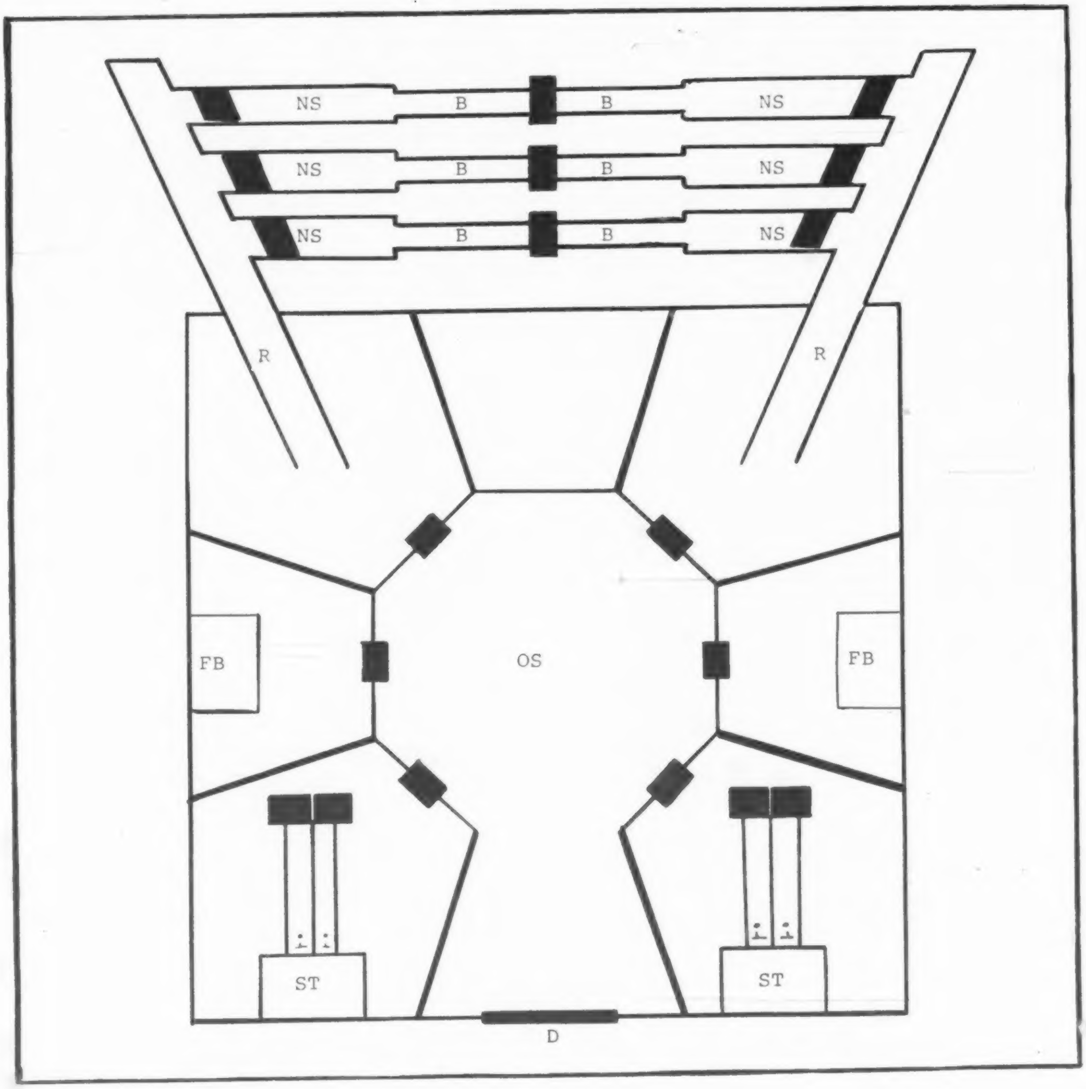

Figure 1: Schematic plan of environment for a group of rats, providing for monitoring of animal motion. The nineteen solid rectangles are portals. The solid single lines in the floor area are subspace boundaries, consisting of two foot sheet metal topped by an electric fence. Other symbols are: FB, food boxes and ST, STAW (Social Training Appratus, Water). There are three shelves (NS) on each side wall of the pen, each above the other. They are reached from the floor via a system of 60° ramps (whose base is in the subspace R). From each shelf six light-tight nest boxes are suspended. Finally, each two shelves of the same height are connected by a narrow bridge B, which actually is adjacent to the door D. An open space OS occupies the center of the pen floor. Outside dimensions of the pen are 9x9x12 feet.

largely from the requirement of visual observation from above the pen.

Two attempts were made to provide choice of path and link the various subspaces in additional ways. The first of these, portal-monitored bridges joining the ends of the nest shelves, are presently in use by the animals as alternative pathways to resources and for escape. Tunnels installed beneath the food area from the ramp base to the water, however, were used by females to build nests and raise litters, in effect eliminating them as alternative paths for motion by the group. To simplify the environment for maintenance and ease of visual observation, the tunnels were removed. These final changes left the environment in its current state, with nineteen portals connected.

Experimental Controls and Observational Data

Three accidental deaths, and the removal of seven additional animals reduced the group from 24 to 14. The removal of the seven animals followed an observation that the level of stress in the group was excessive, as deduced from the amount of wounding and severe withdrawal behavior exhibited by several males.

Food, water, and nesting material are made available in excess in their respective subspaces. The external health of each animal is recorded, any young are removed, and the pen cleaned approximately once every three weeks. A twelve hour bright/ twelve hour dark light cycle is maintained, with the transition from light to dark occurring at 10 a.m.

During the pilot experiment, several instrumental problems were encountered. The resonant frequency of the implant was found to vary approximately one percent with variations in the body temperature of the animal, reducing the number of animals distinguishable by the system. Secondly, the detection system requires that the implant, an LC circuit consisting of a standard ceramic capacitor wrapped with magnet wire, be aligned during passage with the drive and detection coils. Even though the implants had become fixed in the animals body with connective tissue, postures occurring during portal passages occasionally caused them to twist enough to prevent detection. Small ramps encouraging the stretching of the abdominal region during passage reduced this problem, and the rate of detecting animal passages is now estimated to be above 98%.

The Current Study

In order to proceed with the second phase of the pilot study, the group used in the first phase was retained, even though these animals had been subjected to many environmental and social manipulations. In subsequent studies, a controlled environment appropriate to the respective experiment will be maintained during the six month period in which the social behavior of the young rats is developing. The current phase, begun in November, 1971, is essentially a period of visual observation of the social interactions and individual behaviors of the animals concurrent with the collection of data by the monitoring system. At the present time a total of twelve half-hour observation periods are conducted each week, and the monitoring system records approximately 5000 rat passages per day. These two sources of information will be compared as a first attempt to explore the above hypotheses.

The Method of Analysis

The data on magnetic tape, which provides (for each of a sequence of passages) the implant frequency, portal number, and the time and direction of passage, is first decoded by associating the identifying frequency with the rat bearing that implant. This identification is then scrambled, so as to reduce bias in intermediate states of data interpretation. Single failures of detection during a particular passage are patched up and the missing portal passage inserted by examining the sequences of subspaces transversed by the animal.

At the present time we are writing a system of computer codes to analyze the resulting reduced data set. The derived distributions will include: calculation of social velocity (as defined above), frequencies of portal passages by each animal, frequencies of association for each pair of animals by location, and the distribution of duration of each animal's occupation of various subspaces. Duration of occupation of a subspace can be calculated separately for each of the paths crossing that subspace. The number of such paths is related to the number of portals entering that space, or, equivalently, the number of other subspaces linked to it (12).

A second stage of analysis will be to determine the existence of sequences of passages, which may represent either paths or sequences of single behaviors. It should be possible to distinguish between these two cases according to whether the sequence occurs as frequently in a given order as its reverse.

A third strategy of analysis now in the early stages of implementation will trace the motion of any animal on an on-line cathode ray tube. The choice of animal traced, and the rate (or direction) of the motion will be controlled in an interactive mode. For instance, if an animal enters the center area, and is observed to remain there for a long period of time, a display of all other animals in the same space could be requested. The paths of any of these animals could then be traced forward or backward in time. This type of analysis of a social group has not previously been possible due to a lack of data on continuous motion.

Alternative Models

The model developed above essentially describes the observation of social structure within an environment consisting of linked behavioral settings. Either of these two aspects can be developed further, linking this model to other concepts and providing substance for future experiments.

A Model of Status Interchange

Rashevsky presents a mathematical model of economic status based on an interchange of wealth which is dependent on an ability distributed unequally among individuals (13). The distribution of wealth is then derived from this interchange model. The social system under consideration also exhibits a distribution of "status", and one interesting possibility is that space (or volume) is a medium of interchange. Thus advance and retreat on a small scale may give rise to and sustain a status differential between animals. In this connection it is useful to recall that status and rank are abstractions, essentially (in our model of social structure) statements of relative probabilities. Thus it may be true that status is not an integer-valued, but rather a continuous variable, subject to change on various time scales. In particular, the status differential between animals need not be a constant. Our data can in fact be used to test this hypothesis, e.g., whether the social velocity differential $v_i - v_j$ between two animals is proportional to the magnitude of the probability of animal i prevailing over animal j in unsymmetrical interactions.

The existence of a predictable pattern in social interaction implies the association of information (in the sense of information theory) with the social system. That is, far from being random, the social system is in fact entropy-denying, an attribute which it shares with all living organisms. This is in direct contrast to the case of a group of interacting particles (e.g, a gas) where a distributed set of unequal velocities will not be preserved, but the particles, behaving identically, will interchange momentum in a random fashion (14).

The Meaning of Subspaces

It was stated above that a significant consideration regarding the configuration of the environment was the subdivision of the total space into subspaces, each of which may then be considered as a behavioral setting (15). That is, each subspace becomes associated with a particular subset of the total behaviors exhibited within the environment. Interest is then directed toward the qualities of the physical setting which become paired with behavioral expectencies. The food and water spaces are strong candidates for simple settings, although they may become associated with other behaviors as well. If the correspondence between subspaces and behaviors can be reliably established, then the portal passages alone can determine sequences of behaviors. Such sequences for individual animals have been studied extensively by Calhoun (16). The current system, on the other hand, offers the possibility of studying the interrelationships between behavioral sequences for an interacting group of animals. Moreover, if the distribution of duration of occupation in a given subspace exhibits clear structure, that is, it represents the existence of more than one behavior, then behaviors may be distinguishable on the basis of interpassage time intervals. Our observation of individual behaviors in each subspace will also aid in the description of these as behavioral settings.

Environmental Structure and Links Between Subspaces

One of the attractive features of the behavioral setting model is that it permits the breakdown of a complex environment-behavior relationship into (a) the set of settings, and (b) the links between settings. The latter can take the form of distances, channels of communication, conflicts, affinities, etc. The resulting network, in which settings are considered as nodes, may be analyzed by several models.

One measure of the complexity of a network, for instance, is the total number of distinct paths which cross each node in the system. Under certain conditions maximum complexity occurs for symmetrical networks (17). The complexity of the link network is also related directly to the amount of choice available in the environment. Choice of path is very significant in the present study, because it is correlated with the existence of escape routes for the rat. For instance, most rat burrows have multiple entrances, whereas our nest boxes have only one, allowing one rat to trap another in the boxes. Redundancy in the path network also provides the possibility for lower status rats to avoid associates while travelling to resources.

By studying the setting network we can approach the more general issue of environmental structure, and its relation, for instance, to the stability of the social system. It may be possible, moreover, that there is a direct relationship between social and environmental structure, two representations of the information content of the respective subsystems. The correlation of final population density with initial density in a given space is an example of a relationship among the various forms of structure in the total system (18).

The concept of a over-manned behavioral setting is also suggestive in this context (19).

Future Experiments-Social Manipulation

Motivation for this apparatus stemming from studies of population growth and self-limitation has been mentioned. Assuming that our goals of discovering sensitive measures of the social system has been realized, one could allow the young rats, now removed periodically, to remain in the population. Although not implanted, and thus invisible to the monitoring system, they would exert an increasing pressure on the existing structure, and the response of the latter could be observed. The breakdown of the normal social structure is in fact postulated to be a major mechanism by which the associated behavioral changes leading to self-limitation of population growth occur.

A second possible class of experiment is related to an earlier study, where two spatially separated groups of animals were trained, respectively, to drink cooperatively in pairs, or disoperatively, as single individuals. This was accomplished by placing contingencies on the operation of levers in a two-animal drinking apparatus (STAW) (20). The cooperative animals, for instance, developed the practice of waiting outside the STAW for another to arrive before entering. At one point in the study a disoperativeanimal managed to cross the electric fence separating the two pens, and entered a STAW to drink. Immediately a cooperative animal entered beside him. His persistent removal of all animals coming to drink with him resulted in the severe wounding of several of the latter, who, however, never fought back. Nor did the newcomer learn the "value" held by the cooperative rats.

An interesting extension of this experiment would be to provide a choice between both modes of drinking to a group of animals. The number of individuals would need to be large enough to insure that neither STAW alone could provide sufficient water. As mentioned above, the possibility that the environment would be used in such a study was the principal motivation for providing bilateral symmetry. In such an experiment, one could study the interaction between the group which chooses cooperative drinking and the group choosing disoperative drinking, if indeed these choices are stable over time. Their differing use of space, whether one group dominates the other, and whether coop animals drink in predictable pairs, could be examined. A later stage would make the drinking mode dependent on the identity of the animals entering the portals in front of the STAW.

Other psychological-social phenomena of interest could also be studied, e.g., the administration of certain drugs, brain lesions, the use of a group of animals with known, but varying previous histories or the introduction of new members into an established group.

Future Experiments-Environmental Manipulation

In the model of the environment as a complex linking of behavioral settings the effect of changes in one or more settings, or of altering the network of links, or both could be studied. For instance, the change in one setting may affect the use of other settings, or the pattern of paths through the links. Removing a link or adding a new one may change the use of the associated settings. The results of such alterations could be monitored fairly rapidly using the monitoring system.

One of the difficulties in the study of various methodologies in environmental design has been the evaluation of alternative design solutions. Cost-effectiveness measures are relatively straightforward in comparison to determining the effect of alternative configurations on behavior. The design of environments for animals such as the rat, however, provides a class of design problems with distinct advantages. For example, both the environment in the current study, and the subject (as compared to human beings) are relatively simple. The data collection rate of the system would permit rapid feedback regarding the response of the animals to any shift in their environment. The total system could thus be used for experimental design. The possibility of linking environmental manipulations to behavioral responses via interactive analysis on the cathode ray tube further enhances this possibility. The large body of data collectable with the system under various environmental conditions, moreover, would permit relatively easy simulation of the behavior of the system for various environmental configurations.

Dynamic Systems

The inherent dynamic nature of the man-environment interaction, as expressed, for instance, in the phenomena of learning and adaptation, has been indicated (21). The monitoring system would seem to have a potential for the study of the dynamics of the total social/environmental system, for instance, the behavior of the system as it approaches equilibrium after some change, and the stability of the system at equilibrium. Is motion toward equilibrium related to environmental structure? The rigorous exploration of such issues could possibly aid in the design of more responsive environments-environments which encourage growth and learning by their users.

Conclusion

The above description of our monitoring system, the models which seem most useful in describing the data it collects, and some experiments which it may enable us to perform, is essentially a forward look based on a limited contact with the system and its possibilities. We hope to be able to report further progress as we continue in our use of the system, and as we gain from the suggestions of others.

Footnotes and References

1. The research described here has been performed at the facilities of the Laboratory of Brain Evolution and Behavior at the National Institute of Mental Health, Bethesda, Maryland, in collaboration with J.B. Calhoun and H. Marsden. This material will be used as part of a Ph.D. Thesis in Physics at the Virginia Polytechnic Institute and State University, under the direction of W.P. Trower.

2. Archer, J. "Effects of Population Density on Behavior in Rodents", in Social Behavior in Birds and Mammals, Essays on the Social Ethology of Animals and Man, Vol. XLII, John H. Crook, ed. Academic Press, New York, New York, 1970, pp. 169-210.

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   Christian, J.J. and Davis, D.E. (1964). Endocrines, behavior and population. Science, N.Y. 146, 1550-1560.

   Wigotsky, Victor W. (Feature Editor), "Design Implications of Population Growth," Excerpts from "Engineering and the Urban Crisis: Part 3-Urban Congestion", pp. 48-60, Design News, Sept. 15, 1970 Cahners Publishing Co., Denver, Colo.

3. Our ignoring these other behaviors is essentially hypothesizing the existence of significant redundancy in communication among the animals.

4. The significant meaning of "predictably" is "predictable for the animals." For our purposes, this is equivalent to regularities noted by the experimenter.

5. Our model of N interacting entities will assume the validity of superposition, namely, that the totality of interactions may be represented as a superposition of simultaneous two entity interactions. That is, within a social group of animals, at any instant of time, communication occurs only between pairs of animals, or between two animals and "an object."

6. Calhoun, John B. "The Study of Velocity", 1962, (unpublished ms.).

7. Ibid.

8. Calhoun, John B. The Ecology and Sociology of the Norway Rat, U.S. Public Health Service Publ. No. 1008, 1962.

9. Calhoun, John B., "Design for Mammalian Living", Architectural Association Quarterly, Vol. 1, No. 3.

10. Dr. Aristide Esser has recently implemented a radio transmitter system for monitoring the motion of mental patients at the Rockland, New York State Hospital (personal communication). The technology of telemetering over long distances, by contrast, has a long history. However, in most cases the structure of the environment through which the animals move is not known.

11. The requirement of a detection system is that the individual animal or some unit localized within him receive some interrogative signal, add to it information identifying itself, and "reflect" it back to the detection system. Many channels (gravity, ultrasonics, radioactivity, optical, infrafed) are available for this communication. "Active" can be used in two senses here, as originating energy, or originating information.

12. The total number of paths, counting both directions of travel, is h^2, where h is the number of subspaces linked to the given subspace.

13. Rashevsky, N. Mathematical Biology of Social Behavior, University of Chicago Press, 1951, pp. 58-63.

14. Another feature of the social-environmental system which may be set in analogy with single organisms is network of links between nodes, corresponding to a simple, bilaterally symmetric nervous system.

15. LeCompte, W. and Willems, Edwin, "Ecological Analysis of a Hospital", Proceedings of the Second Annual EDRA Conference, Charles Eastman and John Archea Editors, 1970, pp. 236-245.

16. Calhoun, John B., "Design for Mammalian Living", Architectural Association Quarterly, Vol. 1, No. 3, 1969.

17. It appears (from limited calculations performed by the author) that, for the case where a given network of nodes are connected by the maximum possible number of links (this is related to the four color map problem of topology) the greatest complexity occurs when the network is bilaterally symmetrical.

18. Kessler, Alexander. Interplay between Social Ecology, Physiology, Genetics, and Population Dynamics of Mice. Rockefeller University, New York, N.Y. Thesis, 1966.

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THE USE OF ETHOLOGICAL METHODS IN ENVIRONMENTAL ANALYSIS: A CASE STUDY

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Introduction

The goal of this project (1) was to study informal behavior in a public plaza. It was attempted to measure the effects which elements of the natural and designed environment may have on social interactions and activity patterns in general.

As a pilot study leading up to the actual study of the chosen area, informal observations were made in various parts of the campus of Virginia Polytechnic Institute and State University. The sites included dining halls, walkway intersections, courtyards, and fronts of buildings. The criteria for choosing the site for this observational study were based upon a relatively high density of people using the area during the course of the day and a diversity of activities occurring in the setting. A range of physical elements, natural and designed, such as trees, grass areas, hills, shrubbery, gravel, benches, walls, and steps, it was hypothesized, serve as environmental clues in direction finding or in support of certain activities. Thiel (2) described such elements as SEE'S or "Space Establishing Elements."

The particular purpose of this study was to observe and analyze how people reacted to and interacted in an area defined by Space Establishing Elements. They are vital factors in determining how people will arrange themselves spatially for the purpose of interacting with one another, in providing privacy for social groups and individuals, in allowing for movement flow, etc. The position and characteristics of these elements, defined in terms of location, shape, direction, size, color, and texture will potentially enhance or lessen the purpose for which an environment has been designed.

The plaza in front of Squires Hall, the Student Union Building of Virginia Polytechnic Institute and State University, was the setting for this study. The building accommodates a diversity of extracurricular activities. The assumedly great amount of activity generated in and around that kind of space and the required criteria of SEE'S were found worth an evaluation. The plaza connects the first floor of the building on one side with a sidewalk and main auto thoroughfare on the other (see plan on data sheet).

Studies on Human Spatial Behavior

Human spatial behavior can take different forms, whether it occurs with individuals or in groups. Many variables enter into spatial behavior. Among them are psychological variables, cultural factors, physical environmental factors, psychophysical factors, etc. Generally, studies on spatial behavior fall into one or more behavior categories related to certain recurring spatial concepts, such as territoriality, personal space, proxemic relationships or sociofugal vs. sociopetal space. Examples of units of analysis for the various categories named above include the number of aggressive acts or submissions, the frequency of use of certain locations, the number of defensive acts, the distances maintained, the number of successful contacts, sociometric measures and measures of stress, such as heartbeat and galvanic skin response.

For the purpose of measurement behavioral categories frequently are broken down into smaller observable units, such as greeting or verbal communication as manifestations of social interaction. Such units of analysis represent overt behavior episodes which can be recorded and quantified. Current research trends in the field of man-environment relations are partially based upon the fact that humans and animals structure their environment spatially. Originating from ethological studies with animals an area of research has evolved which deals with the determinants of human spatial behavior. Valuable insight was gained from observational studies on how animals define and mark territorial boundaries, acquire and defend territory, communicate and relate spatially to members of their own and other species. Some of the spatial behavior found in animals may still be operating in the human species, transmitted genetically from one generation to the next and acquired through social learning in developmental stages of the life cycle.

Esser (3,4) observed and recorded teritorial and dominance behavior in psychiatric patients, captive gorillas and free-ranging gibbons. He found ordering or submission into a dominance hierarchy within the groups under study. Dominance in this context referred to the spatial behavior of humans and animals, i.e., the observed differences in the way personal territories were intruded or left untouched by others. Under crowding conditions in public space it is conceivable that such behaviors could be observed, if no evasive action could be taken by the subjects. For example, in mass rallies or under stressful conditions, dominant behavior may become quite evident. Relevant to this study is another line of research concerned with personal space and the kinds of behavior which are associated with the acquisition, defense and marking of boundaries of territory. Sommer (5) stressed the importance of maintaining individual distance from other people to avoid "intrusion of personal space". In library studies he observed the defense measures people used against invasion of private territory. A study in small group ecology lead Sommer to the conclusion that there are four major determinants of spatial behavior of individuals. These include the task of the group member (e.g. requiring competitive or cooperative action), personality characteristics, the cultural background and the environmental characteristics of the setting. He found certain regularities in the spacing of people engaged in conversation. Distances and seating arrangements (opposite or side by side) could be determined by the limits at which conversation was enhanced or made extremely uncomfortable. Sommer points out that there may be certain generalizable principles of human spatial organization, based on the fact that the arrangement of sense organs for spatial perception is similar with all humans.

In observing schizophrenic patients Horowitz (6) found that when confronting other people patients would keep a bigger "space bubble" around them than they would when encountering physical artifacts. They found that the size, shape and penetrability of this buffer zone probably depend on immediate interpersonal events, current ego and drive states, and the individual's psychology and cultural history." Personal space, or the distance which people will tolerate or accept in crowding or other situations is largely determined by cultural norms. Hall (7, 8, 9) pointed this out when observing the spatial interaction patterns of people in different cultures. Proxemics is a term coined to describe four principal categories of relationships among people which spatially require different treatment. These relationships (intimate, personal, social, and public) are associated with various zones of involvement indicating the boundaries and distances which are maintained among people. The "space bubbles" surrounding the individual varies with the cultural proxemic context as Hall has shown. A violation of proxemic distances which are more or less prescribed for each culture, some times disguised in etiquette rules, results in conflict situations.

Behavior in Public Places

Goffman (10) stated that individuals tend to arrange and distribute themselves cooperatively in available space. He addressed himself to physical spacing in public places, e.g. for the purpose of conversation it is important that the talk lines be kept open visually. In support of his observation on communication boundaries, Goffman referred to some of the animal studies on spacing which were mentioned above. Depending on the species, the distance which birds will maintain between each other will vary. Goffman did not offer original hypotheses in regard to human spatial behavior, and he provided no methodology which would be useful to assess space-behavior relationships. However, the interest in his work is based on the fact that he created awareness of spatial relationships in social encounters and the rules which govern them. Pedestrian observations made by Wolff (11, 12) showed cooperative behavior among fellow walkers in crowding situations. Wolff was mostly interested in those movements which pedestrians made to avoid bumping into each other. He found that pedestrians cooperated and were forced to follow "sidewalk rules and to adapt their spacing to the existing density of traffic, with resulting changes in walking style and relationships to their fellow walkers". Wolff's study is significant in two ways: First, his findings suggest that rules for acceptable social behavior are followed voluntarily by most pedestrians in order to avoid conflict in density situations of varying degrees. This requires modifications in spatial behavior. The less space is available, the more cooperation is necessary. Secondly, the methods employed by Wolff in gathering his data used participant observation and movie recordings. By taking movies from above, the pedestrian movement patterns could be investiaged in detail by analyzing the movies frame by frame. The spatial distribution of the sidewalk users could easily be mapped as a first step to quantification of observed behavior.

Another interesting study of human spatial behavior was reported by de Jonge (13). Using aerial photographs of outdoor settings in recreational forest parks in Holland, he found varying distributions of people over the observed park areas. The congregation of people in certain locations was ascribed to "valences", the qualities that determine the degree to which people are attracted to or repelled by certain features of the environment. The valences, based on the concept of "life space" developed by Kurt Lewin, may be associated with the following environmental configurations: Close areas, focal points, edge effects, group territory (dominance) and polarization. The "close areas" were those most used because they were near transportation links; entrances, etc.

The "focal points", formed by natural or man-made features in the environment, tended to attract concentrations of people. The "edge effect" was observed along borders or lines of areas which created congregations of park users with higher densities that were found within these areas. The opposite was observed in the so called "island effect" where closed edges on all sides provided for high concentration of people in otherwise less crowded areas. Bounded territories of which there was only a limited number available would become the "group territory" of those who occupied it first. Subsequently arriving visitors would be repelled and had to find territories of their own elsewhere. The concept of "polarization" reflected the tendencies of members of different social classes to pick sites of varying degrees of closeness or remoteness from entrances and zones of activity and disturbances. Polarization, then, expresses the preferences given by different sections of the user group to varying environments for engagement in similar activities. Based on the findings of de Jonge, but on an architectural scale, it was hypothesized that similar effects of designed elements of the environment on user behavior would be found in the setting for this study.

In a related study, Stilitz (14, 15) investigated the effect of stationary groups on moving pedestrians in subway stations and theatre lobbies. He observed stationary groups, as they related to physical elements (e.g., ticket machines, columns, niches, etc.). Queuing affected the flow of movement during varying traffic densities (e.g., rush hour) and the flow of movement in turn affected the positioning of other stationary groups, i.e., waiting people seeking protection from moving crowds. Such shelter, according to Stilitz, was usually found in the vicinity of columns, edges, niches, and corners of the investigated settings. Stilitz differentiated among pedestrian attributes, formal attributes and flow patterns. Pedestrian attributes included situational factors (e.g. rush hour time) and the fact that people take to the route of least appearing effort. Formal attributes were those of most interest to the author in that they attempted to give descriptions of the attractiveness, "containment", connectiveness, and "traversability" of certain spatial configurations, i.e., of those spatial characteristics which appeared to have direct influence on peoples' behavior. Finally, flow patterns are the product of pedestrian and formal attributes. The behavioral inputs and the given physical form characteristics will determine the locations of route patterns, static groups, etc., which in turn affect each other.

Methodology in Ethological Studies

The scientific value of naturalistic research e.g. of direct and active observations of behavior in real world settings has been stressed by Tinbergen (16). Greenbie (17) argued convincingly for the application of ethological methods to analytic studies in urban design. In short, ethology studies the behavior of animals in their natural habitat. If applied to the study of human behavior, certain advantages and limitations of the ethological approach, as described by Hutt (18), can be summarized in the following way: the ethological method tends to capture in a holistic sense the overall structure underlying human behavior in real world settings. Since it is not concerned with controlled and isolated variables as found under laboratory conditions, quantification of variables affecting behavior is more difficult to achieve, as is an exact replication of findings of ethological studies. In contrasting this method, Barker (19) has elaborated on the ecological approach to the study of human behavior in numerous writings. Research strategies for the observation of physical location and movement of animals or humans differ with the purpose of the investigation. Some only employ simple observation and others use hardware. The advantage of contrived observation through hidden hardware has been pointed out by Webb (20).

Not mentioning the ethical problems involved in experimentation with movies and still photography in public spaces, it is obvious that such methods can keep experimenter influence from the subject under study. The same applies to sound tape recordings through hidden microphones and recorders. Systematic observation as a research technique is evolving among researchers of human spatial behavior. The methodology employed by Esser in studying the spatial behavior of mental patients and of free ranging gibbons is most advanced. Random time sampling in connection with exact locational records made on prepared grid sheets and notations of postural behavior allow for quantified data analysis. An earlier attempt in this direction had been made by Jones (21) in the ethological study of social behavior of nursery school children. The method adopted by Esser describes individual as well as interactional behavior on the basis of predetermined criteria. The development of systems for the notation of observed behavior is important for this kind of study. In the case of mapping observed postural activities geographically, graphic symbols or numerical codes representing postural activities are needed. An attempt in this direction was made by Hall (22), who described a system for the notation of proxemic behavior.

Assumptions

Ethological concepts such as those described above were the basis for this study of behavior in a public plaza. It was assumed that certain forms of territorial behavior, proximity relationships and density conditions would be found among the users of the plaza i. e. concepts which have been studied previously in other settings, such as total institutions. Combining such ethological principles with effects of the physical environment on behavior as described by de Jonge, it was hypothesize that certain behavior categories were most likely to be tied to a given set of environmental conditions not evenly distributed in architectural space. This means that features contained in the designed environment may be supportive of "desired" behaviors, e.g. informal activity, interaction etc. In the case of the plaza studies, these features were: benches and planters, stairs, railings, columns and parking meters. In particular, it was hypothesized that the following relationships linking environment and behavior might exist:

a. Stationary behavior was most likely to occur on or near the designed features mentioned above (columns, etc.), and not in the open and "undefined" spaces of the plaza.
b. Interactive behavior would spatially also be tied to the Space Establishing Elements such as those listed above.
c. Movement would influence the locations where interactive behavior would occur.
d. The "connective attractors" like doors and stairs serving as entrances into the plaza would largely determine the density of events in or nearby the direct path between these connectors.

Procedure

The objective of this project was to study unobtrusively spatial-behavior relationships as outlined above. Major steps involved in the study were:

a. Survey of the VPI & SU campus for active places with informal outdoor behavior. Selection of the site for this study.
b. Establishment of the behavior repertoire for the setting, as well as an activity profile for an average day.
c. Recording of behavior events in pre-established categories on standardized data sheets and maps of the plaza.
d. Quantitative analysis of recorded data.

An observational and photographic pilot study was conducted, surveying the campus of VPI & SU for places where students gathered and spent time in solitary and interactive activity. Those places where the observed amount of activity was relatively high were considered for further evaluation. Eventually, the plaza in front of the Student Union Building was chosen as the site for this study. It combined the advantage of relatively large numbers of users with the fact that due to the functions of the building unstructured and informal leisure time behavior was most likely to be found in this setting. The study was carried out in April and May of 1971. At this time of the year informal outdoor activity on the university campus was expected to reach highest intensity, thus permitting the identification of informal activity places and their environmental characteristics.

Basic to the construction of a standardized data recording sheet was the establishment of a behavior repertoire for the plaza. Observations of the setting were made for two full days and occurring behaviors were described. Written down in longhand in form of brief sentences, these behavior descriptions were then grouped into distinct observable behavior categories, such as stationary behavior or movement, which then was broken down further into more subtle units describing body posture and activity the subject was engaged in.

The data sheet for the observation of the plaza was designed to record three basic dimensions of ongoing activity:

1. The temporal dimension, i.e., the time of occurrence, the frequency and duration of behavior events.
2. The spatial dimension, i.e., the locational data on stationary events as well as moving subjects.
3. The behavioral dimension, i.e. body posture, type of activity, etc.

Due to observation setup, only the numbers and sex of the observed subjects could be identified and recorded. For events not provided in the preestablished categories of the data sheets a "comment" column allowed for additional remarks explanatory of the situation. The data sheet was broken down into two parts:

1. A data code sheet was designed for recording behavioral categories which included the following: walking, running, riding, talking, study, eating, solitary-nonactive, playing. Postural categories: sit, stand, lying, leaning, kneel, squat. Additional categories included: date, time, weather, temperature, observer, observation number, coded location of observed event, number of subjects observed and their sex.
2. A gridded map of the plaza was provided for location observation. A grid pattern in the pavement of the plaza aided in identifying locations of subjects.

In a typical observation the mapping data were recorded first before the observer went on to fill out the behavioral categories of observed events in the data sheet. A "behavioral event" was defined as any individual or group of two or more subjects occupying territory of their own in the plaza. Behavioral events, then, were the basic units of analysis and they were recorded as such, with behavioral episodes constituting the finer units of analysis. Observations were made at five minute intervals.

It was established in pilot observations that 5 minutes were necessary to complete the data sheets between observations. Like in a "frozen picture" observations would capture the activity in the plaza at a given point in time. Observations took place over a period of 3 weeks, with each day and hour of the week being represented at least once. The observations took a total of 17 hours and 20 minutes and were fairly comprehensive as far as coverage of the various time periods are concerned. Four observers took turns in recording data for periods of one to two hours at a time. In particularly active periods it was necessary to divide the observation area into two halves and to have two observers cope with the increased amount of data to be recorded. Although video-tape and Super-8 movie recordings were made initially as means to learn about the specific conditions and characteristics of the plaza and for the purpose of checking observer reliability the major method of data gathering for this study was direct simple observation. The observational set-up was as follows: The observer (and cameras) were stationed opposite the plaza, i.e. across the street behind shrubbery in order to remain as unobtrusive as possible. From that vantage point the entire plaza could be overlooked. Observers were equipped with clipboards used separate data sheets for each observation period.

Results: Mapped Data

Using a graphic overlay system a two-step procedure was employed to analyze locational data on movement and stationary activity in the plaza. First, all mapped data for each observational period were transferred onto one map, showing clearly the differences in the amount of use of certain parts of the plaza at different time periods. Next, data of all observational periods were combined and mappings of stationary and movement behavior plotted separately.

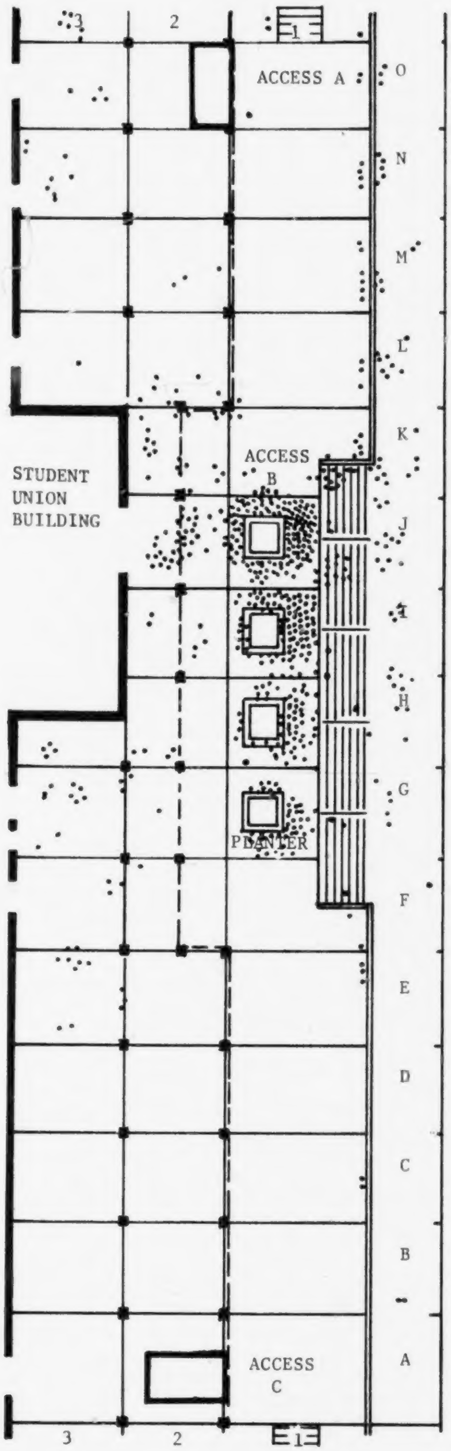
The analysis of stationary data shows that the planters are the places for most of the stationary activity. This phenomenon is not unexpected. The purpose of the analysis is to see how these planters are used. Planters are identified by the quadrant in which they lie. The I and J planters have the greatest amount of activity with the J planter showing greatest concentration of use. As one approaches the G planter, the number of observed subjects is very much reduced, with a large difference in activity between the H and I planters, H having roughly 2/3 of the amount found around I. The major activity center in terms of stationary activities (talking, studying, eating, etc.), therefore, appear to be the I1 and J1 sections. Overall, the south and east faces of the planters generate most of the activity. The front part of the planters faces out onto the street giving people sitting in this position a wide visual field full of interest generating activity.

The I and J planters are the most pronounced examples of the general trend for stationary activity to be occurring near the major building entrance. This also seems to be the place where the greatest amount of physical circulation takes place. The majority of those engaged in stationary activity tend to be in the middle of the overall activity scene. The Squires plaza is a social gathering point, and therefore privacy is not such an important factor as had been thought. This is shown by the predominantly street orientation of the users of the planters and the observed preference of the congested I and J planters. The plaza itself does not accommodate the need for activity and interaction at the personal level because the planters are not close enough together for good face-to-face conversational activity. Other seating arrangements could be investigated regarding their effect on generating conversational interaction. The tendency for the accumulation of stationary activity on or near the busier steps support the notion that generally on the plaza, people tend to congregate or spend time near where most activity is. The railings (K1 to O1) attracted a number of people, particularly near the center of the plaza and big activity areas. Few people at the railings were found interacting with other people below on the sidewalk and on the steps. The mapped data analysis shows clearly that physical features of the environment, whether in the mainstream of movement through the site or not, tend to be used actively for stationary activity, with seating facilities attracting most activity, followed by columns and railings for leaning and free-standing activity.

The analysis of movement data (the graph has been omitted due to lack of space) shows that the primary flow of traffic takes either the extreme right front stairsection (J1-K1) or a path angling across the center of the left expanse of the plaza to and from the main entrance (J2) or the secondary door (F3). Those passing along the "channel" in this left side of the plaza tend to pierce the "column line" according to the direction of their destination or the entrance they are planning to use. The traffic entering the plaza in this area chooses steps at A1 or A3 with most people using A1 because of the direction of most of the campus dormitories. The data sheet shows that front stairs F1, G1, H1 and I1 are not used very much. This seems unusual because most people from campus would be expected to skirt across stairway F1 diagonally to get to the main entrance. Closer analysis indicates that the people coming directly from campus use stairway A1 and those coming from town usually use those at J1, i.e. the right part of the front stairways leading onto the plaza. Contrary to the data on stationary activity where it became evident that vast areas of the plaza remained unused, the movement data show an almost even distribution over the whole area, with high concentrations at connector

DATA SHEET AND LAYOUT OF THE PLAZA

Left: Example of mapped data for stationary activity.
Below: Standardized data sheet.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OBSERVER:
DATE:
TIME:
TEMPERATURE:
WEATHER:

1	OBS NO.					
2	LOCATION					
3	# SUBJECTS PER EVENT					
4	MALE					
5	FEMALE					
6	WALKING					
7	RUNNING					
8	RIDING					
9	TALKING					
10	STUDYING					
11	EATING					
12	SOLITARY NON-ACTIVE					
13	PLAYING					
14	SITTING					
15	STANDING					
16	LYING					
17	LEANING					
18	KNEELING					
19	SQUATTING					
20	COMMENTS					

points, i.e. doors and stairways leading into the plaza. The one sided use of the monumental frontal stairway (quadrants I1 and J1) makes its design concept very questionable.

Results: Computed data

Data sheet recordings were transferred onto computer punch cards for statistical analysis. The total number of behavior events observed amounted to 1,003. Included in this figure were 489 or 49% stationary events and 514 or about 51% moving events, representing averages computed over the whole observation period. Of particular interest in this study were the distributions and circumstances of stationary events, since these generally represented informal interactive behavior among the users of the plaza. Therefore, further analysis concentrated on computations of data on locations and types of events in stationary activity. As could be seen in the analysis of mapped data the tendencies for interactive behavior to occur on or in the vicinity of designed artifacts was very strong if compared with the number of occurrencies of the same category in other parts of the plaza. Leading in the degree of "attraction" exerted on users were the planter sections, with 140 events occurring in quadrant J1 opposite the main entrance to the Student Union Building, and decreasing numbers for the neighboring planters and quadrants facing the stairs (112 events in I1, 59 events in H1, and 57 in G1). As might be expected, considerable interactive behavior was also found close to connectors like in quadrant J2 in front of the main entrance to the building (20 events). The breakdown of numbers of individuals engaged in stationary activity in the plaza was as follows: of the total of 489 stationary events 211 or about 43% represented individuals engaged in solitary activity. Dyads comprised 34% or 167 of the observed events, largely consisting of male-female couples frequenting the plaza. The number of groups with 2 or more persons decreased as the group size increased. For example, 64 (13%) groups of 3, 21 (or 4%) groups of 4, 16 (or 3%) groups of 5 or 6 (or 1%) groups of 6 members were observed. The largest gatherings observed were 3 groups of 7 members, and one group each of 9, 12 and 13.

In order to gain information on how users spent their time in the plaza, the frequencies for the various observed kinds of activity and body posture were computed. In terms of body posture persons in 369 events were found sitting, 147 standing, 34 leaning, 4 squatting, 3 lying and 1 kneeling. Sometimes several body postures were found in the same event. As far as activities are concerned, the majority of events were interactive and involved talking (i.e. in 278 non-solitary events 255 persons were found talking). As the second largest activity group, 115 persons engaged in solitary non-active behavior. The only other two observed categories were studying (17) and eating (12). Lack of space permits this only to be a partial analysis of the gathered data.

Some Temporal Aspects of Behavior in the Plaza

Most observations took place on weekdays. The individual observations can be grouped to show a typical day of activity in the plaza. Morning hours up to 10:00 a.m. were only casually observed with no mapped data due to the fact that the plaza is nearly without activity. From 10:00 a.m. until about noon, activity is sporadic with movement being the dominant kind of activity. After lunch this activity pattern changes as more movement occurs on the plaza but, more significantly, the level of stationary activity rises considerably. Up until approximately 3:00 p.m. a peak activity period occurs and a relatively high level of activity may continue for another half hour or so. However, as the time approaches 4:00 p.m., activity thins out although not reaching the early morning (10:00 a.m.) level for roughly an hour. Supper time (5:00-6:00 p.m.) finds the plaza quiet with activity decreasing to the level found in the first morning observations. Such a level may continue for a half hour after 6:00 p.m., but then the activity begins to pick up again and climbs considerably for both stationary and moving conditions. This period is the second peak of the day and as far as observations show, outstrips the first peak time in amount of activity. Observations were made up until 8:00 p.m. After 8:00 p.m. special events begin to take place in Squires (movies, etc.) which act as extraneous factors in the observational data collection.

Conclusions

As a result of this study several implications for the design of public plazas become apparent. Athough it may not be justified to draw conclusions and to generalize from one case study alone, some of the observed phenomena had been studied previously and were confirmed in this project. Other findings appeared commonsensical since intuitively any designer of a plaza would base his decisions on the suspected effect of certain physical arrangements, e.g. of benches on user behavior. However, with the exception of one study by Stilitz (15) no research is known to the author, in which spatial relationships between behavior and physical artifacts which support it have been documented in quantitative terms. In attempting to judge the quality of a plaza or parts of it, it would seem important to be able to specify not only the desired behavior categories but also the amount of each desired for a particular setting. In this study, value judgements have not been made regarding the "goodness of fit" of certain design elements in the plaza. Instead, the objective was to report on any relationships that might exist, whether good or bad, between elements of the plaza and occurring behavior.

1. Facilities for interaction: Interactive stationary behavior in the plaza was found to occur almost exclusively on or near physical artifacts, supporting the hypothesis that these are actively used when engaging in social contact. Whether interaction happened with persons standing, sitting or leaning depended on a number of circumstances. The amount of time a person could afford to spend in the plaza, whether a person arrived with company or met another person in the plaza or the general aim of the trip will certainly determine the response to given facilities in the plaza. However, seating facilities can be located and arranged in such a way as to encourage interaction or to prevent it. The low number of interactions observed in groups of more than two persons could be explained through the following: distances between planters were too great to permit verbal interaction among users facing each other. The sight lines were continuously interrupted by people moving between the planters. Finally, the square form of the planters forced users to face away from each other. The planters, i.e. the only seating in the plaza situated amidst the main stream of traffic flow from the front stairs to the building entrance, were not suited to facilitate interaction in larger groups. Benches should have been placed in a protected "pocket" of the plaza where interference through traffic could be minimized.

In summary the following observations can be made about general relationships between behavior and designed features of the plaza:

a. Each artifact (bench, railing, column or steps) has an observable radius or field of attraction within which specified amounts of activities take place, depending on the location and time.
b. Each artifact has specifiable predominant categories of behavior which occur at, on or near it, e.g. standing and talking near columns, leaning on railings, or eating only on planters etc.
c. With increasing distance from an artifact its power of attraction decreases linearly to a point where no more influence is exerted by the artifact upon the occurring behavior.
d. Lastly, open or "undefined" spaces are those which are spatially unstructured, i.e. the user finds it difficult to relate to such a space and to spend time in it because of lack of environmental clues which would aid him in carrying out activities such as those found in other structured spaces of the plaza. Therefore, such spaces were "dead" and void of activity.

2. Facilities for Solitary Activities: Places for withdrawal and seating facilities are very important e.g. for study and eating categories which were found to be almost entirely absent from the plaza. Also, in the park areas of this university there are no benches or seating facilities. (The reason given for this by the administration is that littering behavior must be discouraged). Facilities for solitary activity in the plaza were found to be extremely few. Again, stairs, the railings and the front of the planters facing the street were used most where there was a good view of by-passing traffic. Columns served as "shelter" for (standing) interaction as well as solitary activity. However, the vast and dark covered areas on both sides of the building were hardly ever used as the analysis shows. This phenomenon might be based on the fact that there was nothing to be watched in those spaces.

The following general observations can be made:

a. Solitary behavior is to a much higher degree tied to physical artifacts than is interactive behavior.
b. Solitary behavior is occurring mostly where external inputs, e.g. an interesting view will provide the person engaged in no purposive activity,e.g. waiting with stimulation.
c. Solitary purposive behavior, e.g. reading, studying etc. requires places sheltered from the mainstream of circulation.

3. Facilities for movement: Movement routes took rather direct paths between the connectors or entrances to the plaza, i.e. doors and stairs. No clear spaces were reserved for movement and therefore, interference with stationary activities resulted. While only one fourth (J area) of the monumental stairs were used extensively the side stairs leading into the plaza were underdimensioned and had to absorb the major part of traffic from the campus and downtown to the Student Union Building.

4. General Comment: The plaza does not facilitate a diversity of behavior categories which would be desirable to occur. The lack of well defined and "sheltered" spaces conveys the picture of a transient space and generally limits activities carried on in the plaza to a very short time. Movement and stationary behaviors interfere spatially, leaving other parts of the plaza "dead" and unfilled with activity.

Data Summary
Total number of observation hours: 17 hrs. 20 min.
Total number of observed behavior events: 1003
Total number of stationary events: 489 or about 49%
Total number of movement events: 514 or about 51%

Locations in the plaza with observed number of stationary events:

A1 2	B1 1	C1 1	D1 0	E1 2
A2 0	B2 0	C2 0	D2 0	E2 0
A3 0	B3 0	C3 0	D3 0	E3 3
F1 4	G1 57	H1 59	I1 112	J1 140
F2 1	G2 3	H2 1	I2 1	J2 20
F3 3	G3 3	H3 0	I3 0	J3 0
K1 17	L1 11	M1 6	N1 14	O1 6
K2 7	L2 4	M2 2	N2 0	O2 0
K3 0	L3 1	M3 0	N3 3	O3 4

Observed Group Size in Stationary Events:

1	2	3	4	5	6	7
211	167	64	21	16	6	3
43%	34%	13%	4%	3%	1%	0.5%

Observed Behaviors in Stationary Events:

Talking: 255
Solitary non-active: 115
Sitting: 369
Standing: 147
Studying: 17
Lying: 3
Leaning: 34
Kneeling: 1
Squatting: 4
Eating: 12

Recommendations for further studies

Being preliminary in nature this study had a number of limitations which future investigations into this subject area might avoid:

1. The time sample, due to lack of observer time, was not adequate to allow for more than limited generalizations derived from the data in this study. Several time conditions ought to be investigated in the case of a university campus:
    a. Different periods within a study quarter or semester.
    b. Different seasons and their effect on outdoor informal behavior.
2. Observer reliability checks ought to have been made, by having two observers record data of the same setting simultaneously. Lack of time prevented reliability checks.
3. Data recording: In a future study observations could be made less obtrusively by using hidden hardware, e.g. video-tape recordings of the setting. This procedure would have two advantages:
    a. An exact record of data could be obtained with only one attendant checking the equipment and changing tapes.
    b. The recordings could be played back anytime for analysis.
    c. Recordings would be independent of inclement weather conditions which observers were exposed to.
4. Time-lapse cameras might be employed advantageously to record data on movement flow patterns. In this study only a few samples could be taken with this technique due to lack of funds.
5. Interviews were conducted in order to gain complementary data on user perception of certain characteristics of the plaza. This technique could be improved.

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AUSTRALIAN ABORIGINES AND THE DEFINITION OF PLACE

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Introduction

The essence of place lies in the quality of being somewhere specific, knowing that you are "here" rather than "there". Those architects who have been interested in the concept of place - for example Aldo Van Eyck and Charles Moore - stress the separation of inside from outside. Enclosure becomes a very important aspect of place-making which also seems, in some way, to be related to the concept of territory. For these architects, as for many cultures and civilisations throughout history, the establishment of place and the taking possession of it is accomplished by means of building structures and boundaries and personalizing the resulting places in some way.

There is one culture at least - the Australian aborigines - in which the building of structures and boundaries is so unimportant that it becomes interesting to discover whether they have any concept of place at all - and if they do how they define it. This would throw light on the essence of place and the range of means available for defining it as well as the limits of environmental comprehension, cognition and structuring. While other peoples - Tierra del Fuego Indians and Bushmen for example - build no major dwellings they do build cult buildings; aborigines do not. Therefore a survey of the ethnographic literature on aborigines with this particular question in mind, should be enlightening.

I have previously suggested (]) that socio-cultural and symbolic factors dominate the organisation of dwelling space, and have also suggested that this is the case for cities (2). A case study of the Pueblo and Navajo Indians(3) illustrated this point in more detail. The present case study of the Australian aborigines extends the generality of the hypothesis that shelter is only one function of architecture-and that other, and more important functions are the symbolic, place defining and socio-cultural - to any environment in which people live, whether built or not built.

Hunters and Gatherers

Aborigines are hunters and gatherers. As such they share certain general characteristics with that larger group(4). Such people generally live in small groups and move about a great deal. As a result they collect little property and tend to be egalitarian. Their movement is not unrestricted however(5) but confined to specific areas. It is the area within which this movement occurs rather than permanent settlements which defines territory.

Group members share food as well as other possessions and among aborigines articles have been traced through 134 persons.(6) This sharing creates friendship, and social values are more important than economic ones. A web of different reciprocal bonds is expressed through laws, myths, song and ritual, binding people together.(7) This cultural elaboration becomes possible because obtaining food takes remarkably little time. Hunters and gatherers have much leisure time which is used for games and ritual; they are also remarkably well fed contrary to general opinion.(8)

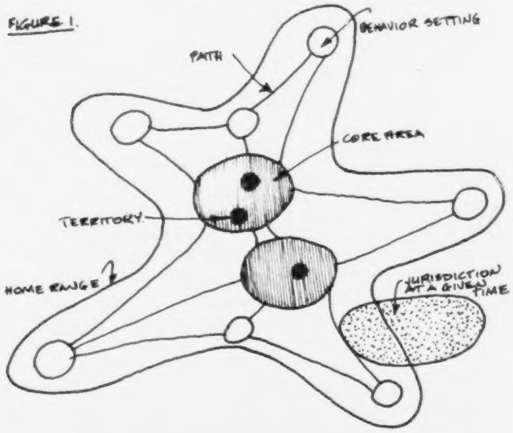
Hunters do not store food but regard the environment as a storehouse. While each local group is associated with a geographic range there is considerable visiting among groups which do not maintain exclusive rights to resources but have flexible arrangements. At the same time most groups have a home base or camp.

This generalised description of the way in which hunters and gatherers (including Aborigines) use space can be expressed in terms of a set of concepts derived from animal studies.

Home range	The usual limit of regular movements and activities, which can be defined as a set of behavioural settings and linking paths.
Core areas	Those areas within the home range which are most used and most commonly inhabited.
Territory	A particular area which is owned and defended - whether physically or through rules or symbols which identify the area of an individual or group from others.

Jurisdiction "Ownership" of a territory for a limited time only and by some agreed rules.

FIGURE 1.



DIAGRAMATIC REPRESENTATION OF HOME RANGE, CORE AREA, TERRITORY AND JURISDICTION, AS DERIVED FROM ETHOLOGY. (COMPARE WITH FALKENBERG, P21. DERIVED FROM A TOTALLY DIFFERENT CONTEXT.)

Among animals the size of home range and core areas and their coincidence, and the times and duration of jurisdiction depend on the natural conditions (climate, rainfall, resources) on the one hand and the animal species on the other. In the case of hunters also the same physical factors play a role as do the values and life-style of the group.

The Australian Aborigines

The social organisation of aboriginal Australia is very complex indeed, as are the legends, myths and art. The contrast of these with material culture is striking and provides another example of the general theme that symbolic elaboration occurs before material elaboration. The application of Western values based on material culture resulted in the evaluation of aborigines as particularly primitive and "brutish".

There is some controversy in the literature regarding the validity of generalising for the whole continent. Worms(9) Birket-Smith(10) Meggitt(11) Hiatt(12) Baldwin-Spencer(13) among others discuss this issue. With regard to the symbolic representations of place it does seem possible to generalise, to accept that in spite of variations in some aspects of aboriginal culture, such as art(14), certain features are sufficiently uniform for us to speak generally of "aboriginal Australia".(15)

Aboriginal Shelter

It is generally thought that aborigines only had windbreaks but this is an oversimplification.(16) In fact aborigines had a considerable variety of dwellings although simple shelters were most common, at least in Central Australia. There were stone walled huts with arched roofs, 2 storey bark huts, cupola shaped leaf huts up to 15 ft. in diameter and so on. Descriptions can also be found of even more elaborate houses such as permanent huts plastered with clay over sods; beehive shaped log huts 4 feet high, 9 feet diameter; log houses 16 feet long; and a variety of other dwellings.

The general point, however, is that aborigines had a much greater variety of dwelling types, and often much more substantial, than is commonly thought. At the same time their dwellings were less important than in most other cultures.

If we accept that dwellings have two functions,

1. physical shelter and
2. the provision of symbolic space and definition of place,

then the Australian aboriginal dwelling seems to fulfil mostly the shelter function although even this is minimal in spite of the often extreme climate. There seems no indication that dwellings fill any symbolic function. Whatever their nature, dwellings do not seem to have much symbolic meaning or rules on layout and use, other than the fact that each shelter or dwelling is for one family and outsiders do not enter without invitation - there are strong feelings of personal space and kinship avoidances. The residential unit, ideally, comprises a composite family of a man, several wives, unmarried daughters and uncircumcised sons.(17)

It is true that the hypothesis that aboriginal dwellings are devoid of symbolic meaning has not been demonstrated directly. The circumstantial evidence, however, is very strong and this may be the only evidence we shall ever have on the subject. As soon as we look at camps, for example, we find that they are arranged along well understood principles and rules differing in different tribes, but quite definite.(18) For example, when several tribes met, huts were grouped by tribes, the spacing between groups of huts being several times greater than between the huts within the group. The arrangement of camps according to phratries and classes reflected and helped to implement ceremonial rules regulating access of various classes to each other. All areas of Australia had specific, complex rules for positioning huts in the camp and while to the outsider the camp may give an impression of disorder there is a structure, such as a division into two halves reflecting kinship, (possibly emphasised by a natural feature such as a creek or hill) or the provision of special bachelors' and spinsters' camps.(19)

At large gatherings in Central Australia, to which some tribes travelled as far as 200 miles, the various camps were arranged so as to indicate roughly the locality of the owner - those from the south camping in the south, those from the north in the north. While camps were as impermanent as huts, the camp was laid out according to definite ceremonial rules.(20) Even a tribe as primitive as the Kurna arranged their camp so that huts were in certain directions and at certain distances from each other according to the relationships of the occupiers. The Arunda camp had eight groups of huts corresponding to the eight subsections into which the tribe was divided. Two neighbouring groups provided communal meeting centres for men and women respectively, restricted to the opposite sex, which can only be visited if approached from certain directions.

Camp divisions are still symbolic in this sense even today. For example, people in multi-tribal camps group according to the direction from which they come.(21) Within the camp, fires seem to be more important than huts. Fires are built and kept going on nights when temperatures are 100°F and no cooking is done - it keeps spirits away.(22) Often, wherever an aboriginal will squat, he will build a small fire even though the main fire is close by, and this in the heat of the day, with no cooking to be done.(23)

These characteristics of the camps provide the first clue to the use of space by aborigines and helps clarify how socio-cultural and symbolic environmental functions are fulfilled. There does seem to be a set of places, but they are not in the dwelling. Some symbolic value and social and ritual rules seem to attach to the camp and the fire. The symbolism of place seems more related to the site and directions, i.e. to the land rather than the dwelling. In fact this will be the problem which will concern us for the remainder of this paper.

The Land

The physical environment of Australia is quite varied. Although most of it is arid, there are wet areas in the North and reasonably watered ones in the East and south East. There are forests, jungles, plains, mountains and deserts. Over much of the country, particularly its arid portions, there are common features - red rock and soil, purple hills, gums with grey-green foliage and white or light coloured trunks, scrub, waterholes, parrots and a number of unique animals and plants.

There are two questions which need to be considered.

1. How do the aborigines use this land?
2. How do the aborigines see this land?

How do the Aborigines Use this Land?

We have already discussed the general use of land by hunters and gatherers. Aborigines live in groups each of which "owns" a stretch of land and has as its basic unit the individual family which, in some tribes, has rights over a specific locality. Although authorities differ, tribes seem to vary from 100-1500 people, averaging 500.(24) In good areas tribal land may be as small as 50 square miles, in arid areas - many hundreds of square miles. (25)

For example, the Walbiri have an area of 40,000 square miles. They see themselves as one people who share a common culture and occupy a continuous territory with definite boundaries; they can draw maps of their own location and adjoining tribes.(26) Tribal borders are respected. Even friendly tribes do not have the right to enter each other's land at will; outsiders may enter an area uninvited only in an emergency (e.g. when starving) and have to recompense the owners. Strangers can enter through social sponsorship while ceremonial messengers and ritual novices with their guardians can travel more or less freely without the need for sponsors.(27) There are thus quite definite, recognised stretches of country and boundaries. These latter are often indistinct but can be fairly exact particularly when they coincide with a natural feature such as water, sand ridge, a grove of trees etc. These boundaries are fixed by mythology and aborigines can draw maps of their own and adjacent territories with relevant details and special features clearly marked.(28)

Different types of territorial understandings and types of demarcations exist and are related to definite sites.(29) They are clearest at totemic sites and other special sites and are less clear between other areas. These culturally defined boundaries do not imply exclusivity or sanctions against trespass. The same objective is achieved by having rules for accommodating people across boundaries.(30) The use of the European term "boundary" suggests more precision than is the case. Normally identification was sufficient demarcation and the main interest was in the symbolic values of a particular place.

Birth and subsequent residence in a locality occupied by a group and totemically associated with it was most important. There were various ceremonies which helped the conversion of non-members to members. Residence in itself only gave economic - not ritual - rights to the immigrant,(31) i.e. there was a distinction of the economic and ritual use of land with the latter more important.(32) It appears that each group had a ritual and social locus and an area whose main importance was economic. Both together formed the ecological life space.(33) The ritual areas had clearer boundaries than the foraging areas; the heartland areas were clear, the other interpenetrated and were more indeterminate.(34) There was usually a ritual tie between a clan and its estate, but also an emotional bond with the land itself. The boundaries of areas were demarcated by episodes in the sacred myths and hence were not subject to revision. All myths mention borders, limits beyond which a myth could not be told, nor song sung, nor ceremonies performed. Since boundaries were set down by supernatural beings they could not be questioned.(35) Each tribe thus knew the boundaries of the country in which it lived and identified with it.(36)

It is, in fact, possible to distinguish ten distinct types of areas among aborigines.(37)

1. Distinctive habitats
2. Named places and localities
3. Totem sites
4. Clan estates and ranges
5. Unused, shared and indeterminate zones
6. Regular camping places, including rock shelters and caves
7. Established ceremonial grounds
8. Networks of paths, fords and crossing places over natural obstacles
9. Places distinct from (7.) where contiguous groups came together
10. Miscellany of capital sites such as watering places, fish weirs, raw material deposits, tool manufacturies, etc.

Thus there is a detailed and complex series of places which can be indicated on maps showing the mythological movements of dreamtime heroes.(38) See Figure 2.

How do the Aborigines see this Land?

Many Europeans have spoken of the uniformity and featurelessness of the Australian landscape. The aborigines, however, see the landscape in a totally different way. Every feature of the landscape is known and has meaning - they then perceive differences which Europeans cannot see. These differences may be in terms of detail (39) or in terms of a magical or invisible landscape, the symbolic space being even more varied than the perceived physical space.(40) As one example, every individual feature of Ayer's Rock is linked to a significant myth and the mythological beings who created it. Every tree, every stain, hole and fissure has meaning.(41)

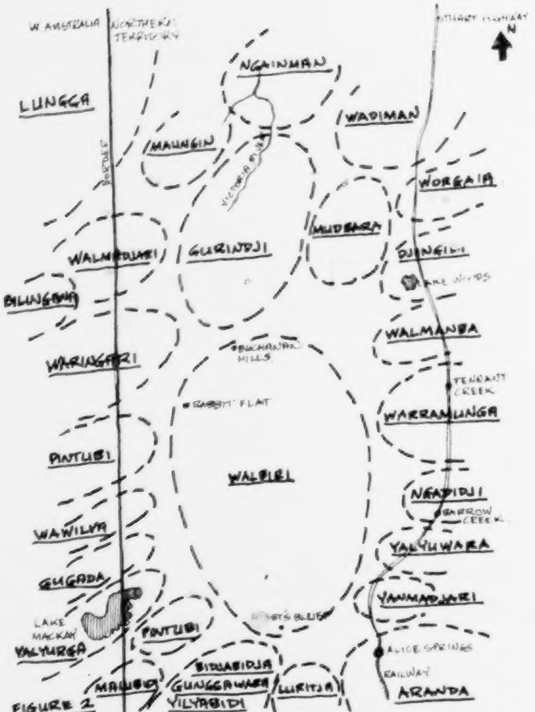

W AUSTRALIA
NORTHERN TERRITORY
STUART HIGHWAY
N
NGAINMAN
LUNGGA
WADIMAN
MAUNGIN
BORDER
VICTORIA RIVER
WORGAIA
MUDBARA
WALMADJARI
GURINDJI
DJINGILI
LAKE WOODS
BILINGARA
WALMANBA
BUCHANAN HILLS
WARINGARI
TENNANT CREEK
RABBIT FLAT
WARRAMUNGA
PINTUBI
WALBIRI
NGADIDJI
BARROW CREEK
WAWILYA
YALYUWARA
GUGADA
YANMADJARI
LAKE MACKAY
PINTUBI
ALICE SPRINGS
YALYURGA
BIDIABIDJA
RAILWAY
MALUGIN
GUNGGAWARA
LURITJA
ARANDA
YILYABIDI

FIGURE 2
APPROX. LOCATION OF ADJOINING TRIBES ACCORDING TO THE WALBIRI SHOWING CLEAR NOTION OF TRIBAL LOCATION. (BASED ON MEGGITT DESERT PEOPLE, MAPS PP 5, 6. TRIBAL BOUNDARIES (---) ADDED AND ARE PURELY FOR CLARITY.
(SEE FIG 4. FOR MOVEMENTS OF DREAMTIME HEROES).

Thus what to a European is an empty land may be full of noticeable differences to the aborigine and hence rich and complex. Europeans may thus completely misunderstand the nature of the landscape because of their point of view. Messages only become meaningful when received and recognised. Signals and signs become perceptual or conceptual meaning through symbols.(42) Symbols thus change the biological and geographical world of signals and signs into a human world of meanings. In this cognitive process, the naming of places has always been important. Naming is more than attaching labels - it confers meaning and significance, it is a process of meaningful ordering of the world. Aborigines as we have already seen and will see later can name a great variety of places in their landscape.

It is thus a likely hypothesis that aborigines humanize their landscape, that is take possession of it conceptually, through symbols - as we do. But whereas our symbols are material buildings, cities, fences, and monuments, aboriginal symbols are largely non-material. They use, as I will show later, natural features, myths, ceremonies and rituals, graphic and plastic symbols - and even monuments. For example, all people have sacred places. Most have then built buildings to stress the sacredness of the site. Aborigines stress this sanctity by returning to these places, by ritual and through mythological explanation of environmental variations.(43) In fact of the total range of devices available aborigines use all except written records, buildings and cities.

The Aboriginal World View

Man may adapt to his environment mentally as well as physically. Through cosmology and cosmogony sets of concepts and categories of thought may be developed through which the world is understood. Categories such as time and space, identity and difference, causality, unity and multiplicity, appearance and reality, matter and spirit are different for people with different world views.

In aboriginal cosmogony the Dreamtime is central. Heroes come to a featureless world and transform themselves into natural phenomena, such as trees and rocks which have sacred meanings associated with the particular heroic figure thus creating the landscape.(44) The Dreaming, when things are made, is not just in the past but also in the present. "All space is here, all time is now" - all appears symbolically and becomes operative through ritual.(45) Thus a sacred site is Dreaming, so are the actors in the ritual and the sacred symbols.

Besides having a different concept of time (46) aborigines also see space differently. It is not something measured - it is an area whose use is dictated by custom. Every yard is known - but not its size. Significantly different is the notion of ownership. Tribal lands are not owned even though groups of people had rights over it. Our concept of property ownership has no relevance to the aborigines' spiritual approach. More important to them is the fact that the people are "owned" by the country - it knew them and gave them sustenance and life. Every person's spirit had pre-existed in this land in the dreaming and no other land, no matter how fertile, could be theirs or mean the same. Men were permanently attached to their own country (47) and wanted to die in it.

This twofold nature of ownership characterizes all secret-sacred objects (Churinga) and sites of mythological and ritual significance (dreamings). For example among the Aranda each individual had a personal stone or wood churinga kept in a secret "storehouse" of the ritual group. The churinga is a lifeline to the spirit world and the dreaming - and people belong to it. The "storehouse" may be a hole in the ground (where the churinga is buried), a hollow tree, a cleft in a rock or a shed of branches. In any case it is concealed from view and the whole area around it is forbidden to women, children and the uninitiated on pain of death. (48) Thus while the concept of a sacred storehouse resembles that of other cultures, it is not expressed by building, and, rather than being stressed is hidden; what is important is that it is known.

A similar relationship exists between ritual groups and natural or artificially constructed dreamings - standing stones, rock masses, waterholes, trees or stone arrangements. These are permanent and symbolic assurances of the presence of the dreaming which are the very ground of being and keep the world going. The whole world is a single entity the main characteristic of which is reciprocity.(49)

Aboriginal Relationship to the Land

From the discussion so far it is clear that the relationship between individuals and groups with their sacred object and sites, and the country generally, is more one of identification than ownership although there are elements of the latter. Boundaries seem to be important more with relation to totemic sites than food gathering areas and these boundaries are defined symbolically by means of legend, myth and ritual.

In terms of perceived environmental distinctions this means that :

a) in terms of the distinction between perceptual and associational aspects(50) aborigines attach many associational values to perceived features of the natural environment;

b) considering the distinction between physical and symbolic space (51) the importance of the latter is greatly elaborated.

Underlying the visible landscape there seemed to be a symbolic landscape which was more real and of which aborigines had a clear notion. This is similar to tribal art generally which expresses "not aspects of the visible world but rather the invisible forces behind that world"(52) and also corresponds to Eliade's view that for primitive man the real world is the sacred world - the profane is unreal. Making the world real means making it sacred, and any feature of the landscape may manifest the sacred.(53)

What, therefore, needs to be considered is the relation of this symbolic world to the physical, the relation between symbolic and physical space. Aboriginal religion, mythology and symbolism need to be considered in relation to the physical environment. This can be done in terms of:

i) the general relationship to the

land and attachment to it
ii) the concept of the Dreamtime
iii) sacred places and totemic sites
iv) ceremonies, symbols, signs, monuments

i) General Relationship to the Land and Attachment to it.

The land, no matter how arid, is home to the aborigines. They are aware of its problems but derive satisfaction from it difficult for the outsider to grasp "...to appreciate this sense of belonging to the land is to begin to understand the aborigines." (54) When shown photographs of buildings, airplanes and cars they are unimpressed but show great interest in scenery, landscape, people and animals.(55) This close relation to the land is strengthened by the fact, already discussed, that hunters treat the environment as their storehouse. Aborigines have few tools or objects and rely on "instant tools", that is they recognise potentially useful objects in the environment. If this object matches a "mental template" or idea of a tool, for example a spear thrower, a concrete object results.(56)

Aborigines, like all primitive people, were not concerned with dominating their surroundings. Their view of life stressed the oneness between man and the rest of nature. Even their supernatural beings and immortals were not beyond human ken but in their midst and related to the land.(57) All writers on the subject seem to agree that aborigines were in balance with nature rather than its antagonists. They co-operated with nature rather than trying to subdue it. There was no sharp line between man and the natural world, its animals and plants. Man did not differ in quality from other species but shared with them the same life essence.

A number of writers report that to keep warm the aboriginal adapted to conditions to the extent of controlling his blood circulation and metabolism. This enabled him to maintain body warmth from a very small fire; rather than building a large fire and sitting far from it the aboriginal built a small one and sat close to it. This lack of conceptual boundaries between the aboriginal and the world was reinforced by the lack of physical barriers such as clothing, houses or walls. While western man relies on such barriers to keep out nature, reduce differences between seasons and times and defines places by manipulating these barriers, aborigines define places by knowing them and their distinctions. This knowledge is perceptual and "real" as well as associational mythical and symbolic; these basic attitudes also prevail all over the continent in spite of local differences.

ii) The Concept of Dreamtime

Every publication dealing with aborigines stresses the central place of Dreamtime. As for most primitive people ritual is central - sacred and profane are intertwined. Religion is an inseparable part of every individual's daily life. Aboriginal religion is nothing less than "the theme of existence and as such it constitutes one of the most sophisticated and unique religious and philosophical systems known to man".(58) This religion therefore is essential for an understanding of any aspect of the socio-cultural life of aborigines.(59) Central to religion, and to all symbolic expression of it, is the Dreamtime.

This concept, existing in almost all aboriginal myths, deals with a period when great heroes and heroines travelled over the land which was flat and featureless - with no mountains, waterholes or living things. All these, as well as fire, laws and so on were created by the heroes whose paths and camping places are described in the myths and form sacred places. Usually the hero dies turning into natural features which are also sacred.

These myths show how closely aborigines are bound to their surroundings, since every feature is mythically related to their origin. The group is linked to the land through the symbolism of myth. Myth is a symbolic statement about society and man's place in it and the surrounding universe.(60) It is an expression of unobservable realities in terms of observable phenomena, (61) in the case of the aborigines the features of their land. The first stories children would hear would explain the creation of natural features. The aborigines thus lived in a world dominated by natural features and the myths linking him with these were a central theme in his life. Most aspects of daily and ceremonial life were linked to the dreamtime creatures and the local topography. Physical features of the environment were personified through the dreamtime - rocks and trees were living evidence of the dreamtime heroes.

The ties to these heroes and the land were kept alive by ceremonial, ritual and art.(62) The whole past history of the tribe was bound up with these ceremonies - and hence the natural features of the landscape as well as ceremonial objects. Often the dead were oriented towards their dreamtime camping ground.(63) Thus aboriginal symbolic space is related to the dreamtime and travel features of heroes rather than compass points. The mythical landscape is superimposed over the physical landscape and they coincide at natural features.

iii) Sacred Places and Totemic Sites(64)

Within the tribe or horde (65) there are ritual groups (clans) associated with natural phenomena or species. The tribe shares a cultural pattern protected by its boundary but clans are more closely related to special sites, identified with their totemic hero and his wanderings. These sacred centres (dreamings) are more closely defined than the food gathering areas, and the sacred clan territory is very different from the relatively profane tribal area. The main tribal link is language (66) while the clan has closer links and a common ancestor. The tribal land is available to all members who share its animals and plants. The clan territory is only fully and freely accessible to initiated men who rarely left it except for special occasions. Married women often lived far from their own clan area but maintained spiritual and emotional ties with it. There is thus more sharing and less exclusivity to food producing areas (relatively profane) than to totemic areas (sacred).

The clan area is thus composed of a number of different totem sites linked by paths while the tribal land is a connected whole surrounding these sites.(67)

The membership of a clan is explicitly expressed by referring to its totemic ancestors and implicitly to its totem sites.(68) Clan membership thus has a spatial component and a special place. Even the larger group is often identified spatially - with an area or camping site.

Some tribes have large numbers of clan territories which can be named and mapped (69) and this has been found in different parts of the country suggesting, once again, that there is some uniformity across Australia. In these clan areas are a number of sacred sites and in each of these a particularly sacred spot - a life centre of natural phenomena, species or objects to which all clan members are intimately related. There are also cult lodges to which men belong. Their churingas are kept in caves, trees or underground and these sacred lodges have no buildings such as one might find, in say, the Sepik River area of New Guinea.

There is thus a clear distinction between sacred and profane, even though there are no visible physical demarcations. For example when churingas were kept in caves, those entering to fetch them impressed palm prints near the entrance to establish rites of passage (70) indicating an awareness of a boundary between sacred and profane. In fact any place where churingas are kept becomes sacred, and the churinga is shown to initiates as a rite of passage giving rebirth into full membership of the clan. Similarly, ceremonial leaders frequently become such in special caves whereas other people who entered these caves would disappear forever.(71) There are thus a number of rites of passage related to environmental features.

Some sacred places are specially related to the conception of children.(72) When a woman conceives in a place where there are prominent features - rocks, boulders, ancient trees - one of the spirit children of the place enters her body and the totem of this place becomes the child's irrespective of the father's or mother's totem. This shows the importance of the place of conception (and camps are sometimes related to it) and the individual retains a special relationship to the natural feature and would worry if the tree is to be cut-down or the rock mined.(73)

Generally, then, the religious and social unit is defined through its relation to spirit beings and special sites. In fact their territory is defined by the sites claimed, which cannot be entered by others who may enter the food gathering area. The land itself represents the most obvious, most enduring and most visible focus of the group. In fact the complexity of the relationship between all social aspects of the group and various sites grows as one goes further into the subject but enough has been said to show the existence of a set of places of distinct levels of importance.

iv) Ceremonies, Symbols, Signs, Monuments

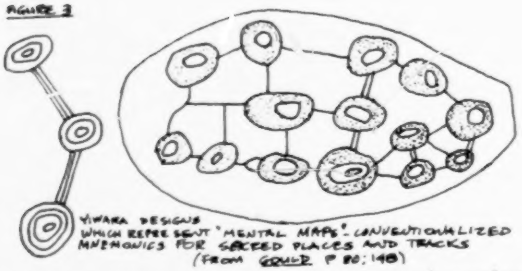
This will be discussed later.

Mental Maps

It has been pointed out several times that aborigines are able to map their "countries", their sacred sites and the tracks of the Dreamtime heroes. In fact the link between the unseen, but very real, mythical world and the physical world is expressed through mental maps. Aborigines have such mental maps which have been studied, but have not been recorded systematically. Some data is, however, available.

Many of the decorations on the few objects which aborigines have, seem to be a series of watercourses along the track of Dreamtime ancestors. Other landmarks such as sandhills, rocky outcrops and saltlakes may be shown. But not all the watercourses of the region are shown, only those throught to have been created or visited by the particular mythological character concerned. They are, thus, not maps in a practical sense but mental mythological maps - mnemonic devices for recalling sacred traditions. See figure 3.

FIGURE 3



YIWARA DESIGNS
WHICH REPRESENT 'MENTAL MAPS' - CONVENTIONALIZED MNEMONICS FOR SACRED PLACES AND TRACKS
(FROM GOULD P 80; 148)

Aborigines can make the most exact and complex maps of the journeys of their ancestral figures and they themselves reenact the journey going in procession from sacred spot to sacred spot, following the divine route. If we remember the processions in tracing the boundaries of Roman (and other) cities (74) we find a similar way of defining place except that it was expressed concretely by building walls. In fact aboriginal areas where sacred objects are stored became sanctified and animals and people in it were safe - an early form of the city or house of refuge (75) but without physical construction.

The Definition of Place

In general terms it appears that aborigines define place through sacred directions, routes of the dreamtime ancestors and their stopping places which become sacred sites, landscape features and the like. Thus an apparently featureless landscape may become full of meaning and significance, legends and happenings - that is full of places.(76) The harsh environment is personalized through ritual and myth bringing its natural features into the realm of the familiar and friendly. Aborigines do not move just in a landscape but in a humanized realm saturated with significations.(77)

In this humanized realm physical features have a larger meaning which makes them part of the associational as well as the perceptual world; they exist in symbolic and sacred space as well as in physical space. This agrees with Eliade's view that sacred space is more real than profane space which is amorphous and formless.(78) Ritual orientation enables reference to some fixed points which are in sacred space. Rather than defining sacred space by building aborigines do it in other ways. By making each natural feature significant they obtain the coincidence of the mythical and physical landscape which distinguishes places from each other and establishes a system of special places. As I pointed out before the mythical and physical landscapes coincide at special features. More specifically, a number of ways in which aborigines establish places and distinguish between them can now be listed.

1. Space becomes symbolic through myths of the Dreamtime.
2. Aborigines repeat the wanderings of the Dreamtime ancestors and reenact various events at ceremonial grounds.
3. Aborigines use sacred paintings and engravings on rocks or in caves and also construct temporary or permanent monuments including the use of body decoration.
4. They construct ritual and ceremonial sites laid out in a sacred order.
5. Places become sacred by having the sacred churingas stored in them.
6. Campgrounds in general are laid out in terms of symbolism and ritual rules.
7. Fires are used to define place.

Some of these have already been discussed - the myths of the Dreamtime, storage of churingas, layout of campgrounds and use of fires. The others will now be described.

Reenactment of Wanderings and Other Events

Aborigines reenact the wanderings of ancestor figures, stopping at specified places - trees, rocks, waterholes, special campgrounds. The paths are followed and acts repeated in a prescribed order. These pilgrimages can be described in quite considerable detail,(79) and the sites and tracks can be mapped.(80) See Figure 4. next page.

The reenactments are complex; stereotyped ceremonies can be clearly described and the pattern of actor's movement can be drawn.(81)

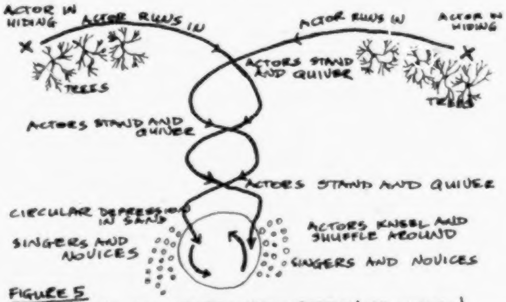
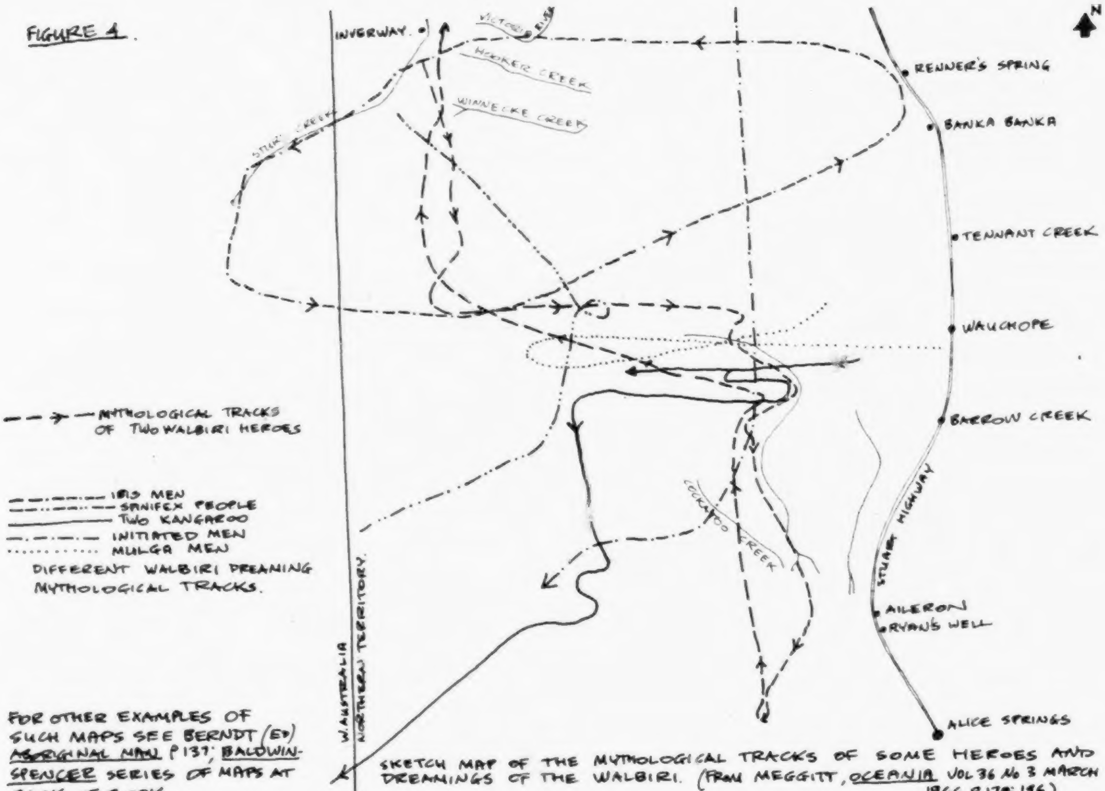


FIGURE 5
CONVENTIONAL AND STEREOTYPED PATTERN OF ACTORS' MOVEMENTS IN WALBIRI CEREMONY.
(FROM MEGGITT, OCEANIA VOL 36 NO3 MARCH 1966 P212)

Some of these ceremonies lasted for months and a strict temporal and geographical order was laid down.

These trips are intimately related to various features of the landscape. Every prominent and many minor landscape features are significant and become sacred places. Before initiation, novices are taught the routes of these dreamtime beings which crisscross the land in all directions. Through the pilgrimages and reenactments of rites links to

FIGURE 4.


INVERWAY.
VICTORIA RIVER
HOOKER CREEK
WINNECKE CREEK
STURT CREEK
RENNER'S SPRING
BANKA BANKA
TENNANT CREEK
WAUCHOPE
BARROW CREEK
COCKATOO CREEK
STUART HIGHWAY
AILERON
RYAN'S WELL
ALICE SPRINGS
N
W. AUSTRALIA
NORTHERN TERRITORY.
MYTHOLOGICAL TRACKS OF TWO WALBIRI HEROES
IRIS MEN
SPINIFEX PEOPLE
TWO KANGAROO
INITIATED MEN
MULGA MEN
DIFFERENT WALBIRI DREAMING MYTHOLOGICAL TRACKS.

FOR OTHER EXAMPLES OF SUCH MAPS SEE BERNDT (ED) ABORIGINAL MAN P 137; BALDWIN-SPENCER SERIES OF MAPS AT BACK OF BOOK.

SKETCH MAP OF THE MYTHOLOGICAL TRACKS OF SOME HEROES AND DREAMINGS OF THE WALBIRI. (FROM MEGGITT, OCEANIA VOL 36 No 3 MARCH 1966 P 178, 196).

the land are set up and the aborigines temporarily reenter the dreamtime.

Places are thus defined by sacred myths which are made concrete through reenactments. Since these reenactments are of the creative wanderings they, in effect, repeat the cosmogony which fits Eliade's point that the ritual of constructing sacred space is efficacious in the measure in which it preproduces the work of the gods.(82) The purpose of reenactment is to show the association between visible object and invisible power - it makes the unseen world visible. The events portrayed are also thought to be in the present as much as at the beginning of things. The time scheme is cyclic and reenactments reestablish these cycles.

Accepting the notion that establishing of places involves making the profane sacred, reenactment rituals do this through words, dance symbolic objects and body paintings used. Intention precedes physical aspects, in fact, physical means in our terms are not essential. In many cultures much ritual symbolism presents the occult as located in the natural environment and its features - aborigines almost stop with this.

It has been suggested that in general there are nine characteristics of symbols with regard to religion, only one of these is the artifactual-actually fashioned and made.(83) Aborigines use all nine - including artifactual. In fact only buildings are not used in the definition of place. Their monuments are not buildings and other constructions added to the landscape but part of that landscape involving at most a rearrangement or reassembly of some of its elements.(84) Other cultures create a new physical landscape in keeping with creation myths. Aborigines structure their existing physical landscape mentally, mythically and symbolically without building it.

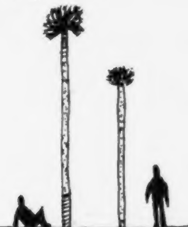
Temporary and Permanent Monuments

Many descriptions and illustrations exist of ceremonies all showing the great variety, richness and complexity of the temporary "monuments" used - body decorations, shields, poles, crosses and the like. Various markers may be erected, rocks emphasized by having blood poured on them or special bough huts built in which men spend much time during ceremonials.(85) During some ceremonials big fires are lit as "temporary monuments".

The various forms of body decorations are extremely complex involving painting, covering the body with down stuck with blood and so on as well as the use of extremely complex, elaborate and tall head gear.(86) People so decorated could be seen as "temporary monuments" claiming a place by making it sacred through linking it with myth.

Various types of poles are erected as "temporary monuments". For example the Nartunja poles which are symbols of natural or sacred natural objects.

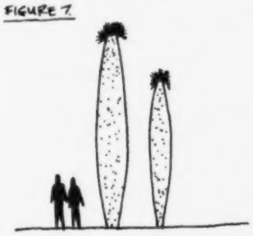
FIGURE 6



CENTRAL AUSTRALIAN SACRED POLES (NARTANJA; KAURNA)
(FROM BALDWIN-SPENCER FIG 43, 44, 81, 84, 86, 88)

Another example are the massive Jelmalandji poles used in rituals throughout Arnhem land, Roper River, etc.

FIGURE 7



A PAIR OF SACRED JALMALANDJI POLES, ARNHEM LAND.

(FROM BERNDT WORLD OF THE FIRST AUSTRALIANS P 375)

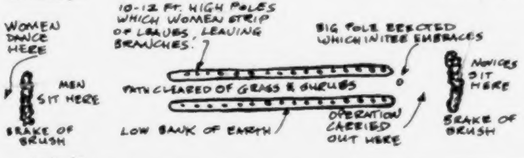
Many other kinds are used and it is interesting to note that Eliade stresses the general importance of the creation and carrying of poles.(87) Other structures are also carried, for example, frameworks with crosses.(88) More permanent monuments are also used. These include rock paintings, rock piles such as at Pukara described by Gould, among the largest and most complex of which are the rock alignments described by Gould (89) which are of a quite impressive scale. See Figure 8. next page.

Construction of ritual and ceremonial sites laid out in a Sacred Order.

The ceremonies of various groups are associated with a particular spot. This may be marked by a prominent natural feature, for example, a great column of sandstone,(90) but in most cases rather complex ceremonial grounds are laid out.

For example, the ground for the initiation circumcision ceremony is placed out of sight of the main camp so women cannot see it and it is quite complex.

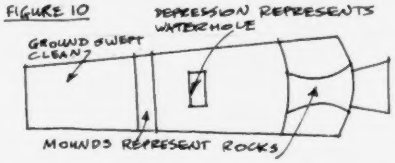
FIGURE 9


AXIS ALWAYS E-W
N
WOMEN DANCE HERE
10-12 FT. HIGH POLES WHICH WOMEN STRIP OF LEAVES, LEAVING BRANCHES.
BIG POLE ERECTED WHICH INITEE EMBRACES
NOVICES SIT HERE
MEN SIT HERE
PATH CLEARED OF GRASS & SHRUBS
BRAKE OF BRUSH
LOW BANK OF EARTH
OPERATION CARRIED OUT HERE
BRAKE OF BRUSH
0 5 10FT

GROUND FOR CIRCUMCISION CEREMONY, CENTRAL AUSTRALIA (BALDWIN-SPENCER P219; 245)
(FOR OTHER EXAMPLES SEE IBID, FIG 77; MEGGITT OCEANIA VOL 36 No 4 JUNE 1966 P 309)

For the Jirinda ceremony at Yirrkala the ground is swept clear and on it are arranged mounds of sand (representing rocks) and an oblong depression representing a waterhole. The whole Bugalub ground represents a sacred ranga emblem. Other Bugalub grounds are arranged with the sand mounds and depressions arranged differently.

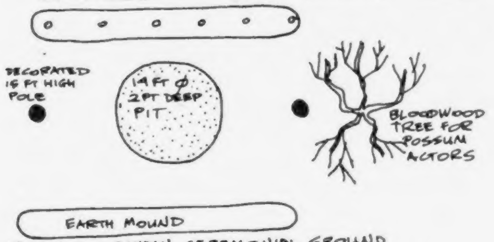
FIGURE 10


DEPRESSION REPRESENTS WATERHOLE
GROUND SWEPT CLEAN
MOUNDS REPRESENT ROCKS

EXAMPLE OF GROUND FOR SACRED CEREMONY (BUGALUB) ARNHEM LAND. REPRESENTS SACRED RANGA EMBLEM
(BERNDT ABORIGINAL MAN IN AUSTRALIA P198; SEE ALSO P199.)

Many other types of ritual grounds are also used. One example follows :

FIGURE 11

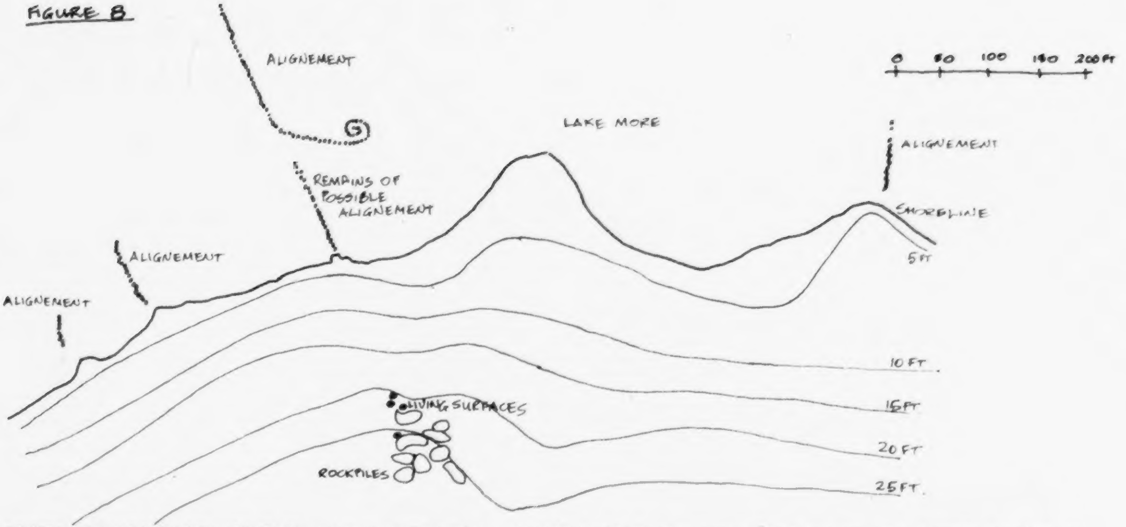

EARTH MOUND WITH CREMOPHILA BRANCHES
DECORATED 15 FT HIGH POLE
14 FT ⌀ 2 FT DEEP PIT
BLOODWOOD TREE FOR POSSUM ACTORS
EARTH MOUND

WALBIRI BIG SUNDAY CEREMONIAL GROUND
(FROM MEGGITT OCEANIA VOL 36 No 4 JUNE 1966 P 309.)

Conclusion

In the largest sense the making of places is the ordering of the world, the clarification of the differences between places some of which are more significant than others. It is making visible of a special space - in the case of primitive people sacred space which constitutes a break in the homogeneity of indifferentiated space(91) and hence a place. I have tried to show that without building axes, sacred precincts, buildings or cities aborigines were able to make the world theirs through symbolic means and achieve a stable

FIGURE 8



SERIES OF ALIGNEMENTS, INCLUDING MAJOR SERPENTINE ALIGNEMENT 240FT LONG (FOR DETAIL SEE GOULD P140) (FOR DETAIL OF ANOTHER COMPLEX ROCK ALIGNEMENT, APPROX 160FT. LONG SEE BIR P145.) (FROM GOULD P140).

world consisting of places.

Our discussion of aboriginal place making is also a good illustration of Langer's concept of making visible an Ethnic Domain through the use of symbols. She stresses the importance of the congruence of symbols and whatever they are to mean.(92) By using natural features, the physical structure of landscape becomes congruent with mythical structure and hence humanized. If architecture is the mode of creating virtual space, making visible an ethnic domain and setting up a sphere of influence, (93) then aborigines create place by giving meaning to sites in terms of their culture - their ethnic domain. They do what architecture does in all the ways described - but without the architecture.

Sorokin draws an implicit continuum between groups for whom shared spatial domains become an important symbol vehicle and those where they are not important - for example learned societies.(94) Aborigines are very much in the former category. Authority was based upon the land and most art, song, myth, dance and so on was linked to the land. This helps explain the rapid psychological and cultural breakdown of tribes when their lands and sacred sites were taken away. The link to these places was crucial because their title to the land went back to their very creation.

It thus seems clear that the Australian aborigines were most definitely able to establish a sense of place which was independent of any buildings or permanent settlements which they might have constructed. This suggests that in the larger sense the establishment of place is a cognitive process achieved through symbolic means. The use of physical barriers is only one way of achieving this although, apparently, an essential one in our culture and context. At the same time the application of these findings may throw light on the nature of environmental schemata, cognition, orientation and symbolism. By comparing the ways in which aborigines define place and structure the environment with the ways in which other peoples do it, we may gain additional insight into these most important mental processes.

Notes

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59. Berndt *op cit* p xv

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61. Leach in Ibid p 1

62. See Falkenberg *op cit* p 85-86; Mountford *op cit* pp 17; 25; 197-199

63. Baldwin-Spencer *op cit* pp 119; 122; 497

64. Most of this discussion is based on Falkenberg *op cit* specially pp 7; 11; 16; 21-22; 114-117; 139; 271.

65. There is some disagreement in the literature about the presence of tribes, the meaning of horde, and their relationship. All agree, however, that some form or larger grouping exists.

66. cf Eliade *op cit*; Gould *op cit*; The Ancient Greeks.

67. For a diagram of this see Falkenberg *op cit* p 21. Note the close resemblance of this to the home range, core area, territory model proposed earlier in this paper-

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85. Baldwin-Spencer op cit p 191

86. For example see Berndt Aboriginal Man op cit Baldwin-Spencer op cit, in fact any illustrated book on the aborigines.

87. Eliade op cit p 32 ff

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89. Gould op cit p 137 ff

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4: THE INTERFACE BETWEEN BEHAVIOR AND MILIEU IN A TOTAL INSTITUTION

ORIENTATION TO THE RESEARCH SETTING: TEXAS INSTITUTE FOR REHABILITATION AND RESEARCH (1)

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Abstract

The setting and guiding principles for an ecologically oriented program of research on institutional health care are described in this introductory paper. The following principles are discussed: (a) the strategy of the ecologist and naturalist, (b) emphasis upon patient behavior, (c) emphasis on overt behavior rather than subjective data, (d) the inductive approach, and (e) the use of a multi-purpose data pool. Papers illustrating the behavior setting survey, the study of roles, and direct observation of patients are introduced as interdependent parts of the program of research.

* * * * *

Hospitals are complicated systems among whose central purposes are the delivery of care, treatment, and service. The Texas Institute for Rehabilitation and Research (TIRR), where we are conducting the research reported here, is no exception. Located in Houston, Texas, TIRR is designed to provide rehabilitative care to persons with chronic physical disabilities resulting from spinal cord injury, stroke, polio, and cystic fibrosis. In our research, which began in 1968 and is continuing at present, we are working toward three major goals. The first is to provide the hospital with continuous feedback and evaluation of its procedures and arrangements. The second is the basic behavior science objective of promoting understanding of human behavior and experience in relation to their environmental context. The third goal, which we will illustrate in the papers to follow, is to formulate a paradigm case for institutional research, an investigative program with a particular flavor, which will have wide applicability to the needs of planners, members, and evaluators of institutional systems, such as hospitals, schools, prisons, and residential systems.

The papers by William F. LeCompte, Edwin P. Willems, and Richard H. Futrell illustrate three concrete aspects of this research program. Allan W. Wicker's paper presents the comments and concepts of an interested outsider and addresses the more general problem of congruence between behavior and the setting within which it occurs. Before proceeding to those papers, a word is in order regarding the overall thrust and character of the research and the principles that have guided it. In a sense, we are delivering an installment payment on the promisory note offered by LeCompte and Willems' paper at last year's EDRA meeting (2).

The Research Setting

Partly because of its enviable reputation among rehabilitation hospitals, TIRR represents an interesting model for study. Understanding the contextual aspects of the delivery of health care in that setting will tell us much about how it can be and should be done.

One of the hospital's principle patient groups--the target of our research--comprises adults with traumatically induced injuries to the spinal cord, e.g., resulting from automobile accidents, industrial accidents, gunshot wounds, and recreational accidents. The magnitude of paralysis and behavioral impairment for these persons is a function of the level and extent of the injury to the spinal cord, but the two primary diagnostic labels are quadriplegia and paraplegia. Two issues make this population and its treatment provisions important for our purposes. One is that while many such persons can be rehabilitated to function with astonishing degrees of independence and effectiveness, the process of rehabilitation is usually arduous, time-consuming, and expensive. Thus, increasing the effectiveness and efficiency of that process becomes an issue of great importance. From the research standpoint, understanding how that process works, evaluating it, and changing it with informational feedback are the important burdens. The second issue is more general. The persons whose behavior and care we are studying represent a group from whose behavioral and adaptive repertoires huge components have been erased. One primary purpose of the hospital treatment system is to restore and replace as much of those repertoires as possible--a complicated and demanding task indeed. Furthermore, over the period from injury to optimal rehabilitation, the spinal-cord-injured person evolves from complete dependence upon the mediating care of his environment for survival to a stage of relative independence and readiness for life outside, all over an average period of 90 to 100 days. Thus, from the general investigative standpoint, changes in behavior and its environmental links can be studied in their entirety, many times over. This intensification of the behavior-environment problem represents a manageable microcosm within which research techniques and conceptual tools can be developed and tested and within which a high yield in information can be gleaned.

TIRR, being both committed and self-evaluative with respect to its mission, frequently introduces changes, in staff assignments, treatment programs, and facilities. Thus, we are provided the rare opportunity to study a behavior-environment system in its course of evolution.

Guiding Principles

Throughout our research, we have tried to maintain the stance of the ecologist and naturalist. For us, this has had a number of important implications. First, we have sought to generate a pool of descriptive data using techniques of research that disrupt the workings of the hospital as little as possible. Thus, we have emphasized independent observation of ongoing behavior and procedures and de-emphasized techniques, such as experiments and questionnaires that require the subject to interrupt his everyday behavior and do something special for us. Second, we have given careful attention to this hospital as a habitat in which the behavior of patients and staff is embedded and with which it is linked. Third, most of our data, analyses, and emerging models are system-wide in character. We have assumed that the hospital as a whole is an interdependent behavior-environment system whose diverse activities and functions all combine for one central purpose: to deliver care, treatment, and service to patients. Thus, our data come from the treatment system as a whole and from intact groups within it, rather than from representative samples. Fourth, we have sought to state our descriptions and measures in language that is understandable to members of the hospital system as well as to us. Esoteric categories have been less important to us than the elucidation of hospital process and functioning. Thus, we tend to generate information that is low in mystery and abstraction and which responsible agents can use in a rather direct way. Fifth, our data are not strictly psychological in the sense of focusing on the inner, subjective worlds of the persons we study. Our intent usually is to probe deeply inside the skin of the institution and its subparts, but to stop at the skins of the persons who inhabit it. Finally, although it has been our intention to stay very close to the actualities of a single institution, the concepts and methods should have wide generality and application. Thus, our purpose in the present paper is to illustrate the methods and some of the findings.

The second guiding principle refers to the point at which our investigative and descriptive case is anchored. Many anchoring points are possible, e.g., cost accounting and cost-benefit data, staff turnover, attitudes, etc. As our continuing point of departure, we have chosen to focus on the actual, ongoing behavior and experience of patients and staff--what they do, where they do it, and the relation between the two. We have chosen this anchoring point because we reason that it represents the crux, the pay-off point, of hospital functioning, i.e., what patients and staff do over time best describes what the hospital really is.

Closely related is the principle of behavioral emphasis. A. E. Parr (3) has argued:

> "Any experienced traveler knows that there are cities and districts where he can walk for hours and miles before feeling any fatigue, while the prospects of other towns make him feel tired almost before he gets on his way. ...There are places that invite relaxation, spectatorship, and meditation, and others where it seems impossible to take our ease without fretting. There are surroundings that make us feel lighthearted, or even exhilarated, and others that tend to put us in a sad and brooding mood."

Parr is referring to the relation between place and mood--how it looks, how it feels, and the feelings it elicits. In fact, environmental psychology has developed a preoccupation with environmental impacts on moods, feelings, and perceptions (see Craik, 4). Such data are important, but they are not enough. Following the lead of the ecologist, we have chosen to focus upon place and behavior--what persons do in the hospital. We have chosen this because not only does the ecological orientation emphasize adaptive behavior, but the major goals and purposes of the rehabilitation hospital are stated in terms of behavior, change in behavior, and behavioral accomodation to the environment.

Another dearly-held principle of the research is hinted at by F. Scott Fitzgerald, a very subtle and perceptive social commentator, in the prologue to his short story entitled, "The Rich Boy."

> "Begin with an individual, and before you know it, you have created a type; begin with a type, and you find that you have created--nothing. That is because we are all queer fish, queerer behind our faces and voices than we want anyone to know or than we know ourselves."

This is just as true in the investigation of behavior-environment relations in an institution as it is in the study of persons. Rather than beginning with the imprimatur of a priori, preset categories and typologies of a hospital system and the behavior that occurs within it, we have begun with the actualities of what persons do in the hospital, described these phenomena with strong procedural guidelines but few typological rules, and asked our observations and descriptions of the phenomena to dictate the typologies. We began with little more than some general beliefs in the importance of viewing a system, the importance of behavior and behavior change, the importance of links between behavior and context, and, in a sense, Studer's concept of the prosthetic environment (5): "...the designed environment can be analyzed as a prosthetic phenomenon. ...it is behaviorally prosthetic in that it intentionally configures specific behavioral topographies." There are pitfalls in working this way, of course, but we are convinced that there are powerful advantages in not having placed upon our hospital such common stamps as unidirectional status hierarchy, semi-closed communication system, pyramidal bureaucracy, transitional interaction sequences, or even the architect's blueprint. As can be seen from the papers to follow, some typologies and classifications are emerging, but we feel that they are relatively close to the day-to-day actualities of behavior in the hospital system.

One way to summarize all this is to characterize the data pool we have sought to obtain. We have generated a common pool of systematically gathered information which can be, has been, and will continue to be tapped for each of the following purposes: (a) Detailed naturalistic descriptions of an institutional environment and behavior within it. Extensive description of a behavior-environment system in operation is the starting point of ecological research (6, 7, 8). (b) Basic, theoretically oriented research and testing of hypotheses. (c) Evaluation of the extent to which the hospital and its subparts are achieving its purposes. (d) Planning of changes in the hospital and evaluation of the impact of those changes. (e) Information for the education and training of staff members and other professionals interested in health care. (f) Examination of location dependencies and site specificity in the behavior of members of the hospital family.

We are studying a hospital, not the hospital. However, it is clear to us that we are studying a very good hospital--one with open, self-critical, nondefensive attitudes. Its members--administrators, staff, and patients--have both the self-confidence and the commitment to allow us to observe them at close range and to describe their work, sometimes in rather probing and intimate detail and, more importantly, to publicize the methods and findings as a prototype for the analysis of hospital health-care delivery systems.

The Research Program

The delivery of rehabilitative care and treatment calls upon the services of many persons and groups and demands the orchestration of these services, together with facilities, equipment, and various forms of expertise into a coherent, ongoing system. Adapting the system to individual needs and to patients who vary along the continuum of progress demands flexibility, flexibility that must occur within the ridigities provided by professional training, scheduling demands, availability of resources, and physical facilities. The day-to-day and hour-by-hour manifestations of all this occur within the walls of the hospital as a bounded institution. However, within those broad boundary conditions, we are much less sure that the architectural plan represents the grid of meaningful subdivisions within which the hospital carries out its business. Thus, one research problem is to discover and describe the way in which the hospital divides itself into subparts, to document the environmental, ecological topography in terms of functional arenas of activity. This is the task of the behavior setting survey, as illustrated in LeCompte's paper.

The pursuit of a complex task with a multidisciplinary work force requires a network of reliable, widely shared assumptions about who will do what. The clarity with which the institution as a whole pursues its purposes is reflected in the extent of agreement among organization members regarding their functions and roles. The paper by Futrell illustrates our attempt to tap into the hospital system at the level of the perceptions or judgments borne by hospital members with regard to each other's roles. The emphasis is upon the extent of agreement or consensus about who is to do what, but the mutuality of day-to-day grouping and exposure among groups turns out to be an important influence on consensus, illustrating the importance of locations, or behavior settings, in the behavioral organization of the hospital.

The behavior setting analysis and the analysis of consensus about roles provide two intertwined aspects of hospital structure--they divulge two different but related aspects of the system. Metaphorically speaking, it is through the tapestry of such environmental patterns and structures that the threads of patient behavior are woven. So, there is the third aspect of hospital functioning that we like to characterize as the crux--the payoff point--of the system's workings: the behavior and experience of patients. Willems' paper illustrates some of our uses of data gleaned from the direct observation of patients. In a sense, it is here that the functioning of the hospital system becomes clearest. It is here that we view firsthand the powerful linkages between patient behavior and the settings in which it occurs and the profound dependencies between locations and many aspects of the dynamics of patient behavior.

The design-and-behavior movement badly needs to accumulate a store of basic information so that environmental planning can grow beyond its traditional basis in folklore, common sense, pet ideas, hunch, and bias. Filling that need will require investment of energy in painstaking research, in which devoted attention is paid to what the users and inhabitants of facilities do. Before we create grandiose theories and models and before we attempt to do good things, we need to develop the substantial grounds upon which to judge between good and harm. Kenneth Boulding wrote recently that the year 1910 was a crucial one for the medical profession because that was the year it began doing more good than harm (9). Whether Boulding is right or not is beside the point. More important is the point that, at present, not only can we not tally up good and harm, but we are hardly in a position to tell the difference. Ultimately, in environmental planning and intervention, the basis for that judgment will come only if we find out much more than we know now about the way in which human behavior becomes linked and implicated in environmental systems.

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1. The research reported here and the preparation of these papers was supported by Research and Training Center No. 4 (RT-4), Baylor College of Medicine, funded by Social and Rehabilitation Services, USDHEW.

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BEHAVIOR SETTINGS: THE STRUCTURE OF THE TREATMENT ENVIRONMENT (1)

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Abstract

The present report describes an ecological survey of a rehabilitation hospital for a 12-month period. The behavior setting unit is defined and used to generate comparisons between (a) patient and nonpatient sectors of the treatment environment, (b) areas controlled by different types of hospital personnel, and (c) indices of importance and visibility. Results indicate little redundancy in activity patterns among professional groups. Patients inhabit a restricted part of the treatment environment, with greater exposure to nonprofessionally trained staff. The importance of structural units in studying complex, developmental processes such as rehabilitation is emphasized.

* * * * *

Introduction

The present report is designed to achieve three goals of increasing generality. First, it describes some results of the behavior setting survey of the treatment environment of TIRR. In the process of systematic description, comparisons are used illustratively, as specific examples of the type of information that can be generated when ecological methods are applied to the study of complex institutions. Second, some features of the regions in the treatment environment inhabited by patients and by staff are presented, in order to provide a contextual framework for the forthcoming papers by Willems and Futrell. Finally, and most generally, it is hoped that this report can provide a model for the investigation of naturally occurring, bounded social systems with methods that are precise, quantitative, and which generate interesting comparisons.

The Behavior Setting Unit

As defined by Roger Barker (2) and as used in previous research, the behavior setting is a stable combination of behavior and nonpsychological milieu with the following properties:

1) a recurrent pattern of behavior, and
2) a particular milieu complex, occurring at
3) a specific time and place with a
4) congruent relation between behavior and milieu.

It is important to note that behavior settings are not created by an investigator but rather are discovered by his investigation of an environment. Thus, they constitute naturally occurring ecological units which are given a more precise scientific definition, but which are frequently discriminated in a highly reliable fashion by the people who inhabit an environment. Examples of behavior settings at TIRR are: A one-man office, a nursing ward, the cafeteria, the general treatment area in Occupational Therapy, and the hallways.

With the aid of the definition given above and the procedural steps described by Barker (2), the total treatment environment at TIRR was unitized into 122 behavior settings for the survey year beginning July 1, 1968 and ending June 30, 1969. The information about the procedure of unitizing the treatment environment has been reported previously and need not be repeated in detail (3). In short, the same level of interdependence between settings as was used in earlier studies of communities (4) and high schools (5) could be used also to reliably discriminate among hospital settings.

In a test of reliability of the unitization procedure, three judges independently rated the percentage of dependence among six activity areas, taken two at a time, within the Physical Therapy department. This sample of possible behavior settings was deliberately chosen from the same department to provide the most rigorous test possible. Had the sample of areas been randomly chosen from different parts of the treatment environment, most of the judgments would have been more gross and consequently easier to make, resulting in artificially high percentages of agreement.

Results of the unitization study were analyzed in two ways: First, the set of 12 comparisons made by each judge was ranked according to the percentages of overlap between each comparison and the ensuing set of three rank orders was statistically evaluated to determine the average degree of judge-agreement in all of the comparisons. Kendall's coefficient of concordance, calculated on the data described above produced a value of .92, which is highly significant and indicates that the three judges made very similar discriminations.

Secondly, the judgments were analyzed to determine the degree of agreement on the critical level of interdependence that was used as a cutting point for inclusion of a setting in the survey. That is, below the cutting point, the percentage of dependence between two activity areas was too great to define both areas as separate behavior settings. In general, it was found that the average agreement on the inclusion of behavior settings was over 90 per cent.

Sectors of the Treatment Environment

Each of the 122 behavior settings that had been discriminated was surveyed for such basic items as physical size, the number of times the setting occurred during the survey year, the number and type of personnel that were involved, and the pattern and types of interpersonal activities that characterized the setting. Reliability on these items tended to be quite high, although less agreement was reached on the more judgmental items.

Perhaps the most basic division in the treatment environment concerns the presence or absence of patients in the behavior settings. The latter sector, those settings from which patients are excluded, can be labeled as "backstage" in Goffman's (6) sense, where important decisions are often made by professional staff regarding a particular patient's program. Some representative backstage settings include: chart rounds, where a doctor reviews his patient load with the professional staff, offices of heads of departments, departmental staff meetings and nursing stations. Table 1 presents some data comparing the backstage and frontstage sectors of the treatment environment.

Table 1
Backstage and Frontstage Settings at TIRR

Index	Patients Present	Patients Excluded
1. No. of Behavior Settings	76	46
2. Occupancy Time (Person-hours/year)	1,098,281 hrs	217,904 hrs
3. Mean size of Settings (Longest diagonal)	35.20 ft	27.37 ft
4. Mean No. of different types of personnel per Setting	4.45	4.09
5. Mean No. of different types of objects per Setting	31.40	27.11

The first line of Table 1 contains surprising data on the extent of the backstage. The 46 settings from which patients are excluded represent 38 per cent of the total treatment environment. Line 2 in Table 1 indicates that approximately 1/5 of the total time spent by people at TIRR takes place in backstage settings. As might be expected from our usual stereotypes of the "smoky back rooms," Table 1 also indicates that the backstage settings are physically smaller, and are more specialized in terms of the variety of staff and of behavior objects.

Also interesting is the relative amount of time spent by staff members in these sectors of the treatment environment. Physicians and administrative personnel inhabit backstage settings approximately four hours for every hour they spend in the patient sector of the treatment environment. Together, they contribute more than 65 per cent of the total occupancy time in backstage settings. Nurses, and aides and orderlies, on the other hand, spend far more time on the frontstage, and can be regarded as front-line personnel. Other professional staff, such as occupational and physical therapists, vocational counselors, and social workers spend a more nearly equal amount of time in the two sectors. The latter groups may function as a kind of communication bridge, bringing data on patients to the backstage and instructions to personnel on the frontstage. These data support a notion of the physician as a kind of "backstage controller," sending messages to the patient and hearing about his progress through intermediaries. Such a view seems implicit in the remarks of one patient to the question: "What does the doctor do?" He answered, "He coordinates the whole thing; otherwise everybody'd be just running around."

One way of generating data directly on the characteristic activities of the staff is to observe them at work in the behavior settings where they function as the dominant performer, or leader. The dominant performer has been defined as the position with most control over the activities in a behavior setting. As the dominant performer "struts his stuff" in the area where he has most control, his performance should be most characteristic. Following this logic led to a further classification of the settings in the treatment environment according to dominant performers.

Querencias: The "Stamping Stations" of the Staff

To minimize confusion over these steps in classification of behavior settings, a term was borrowed from the bullfights to denote any area controlled by a dominant performer. The biographer of the Spanish poet, Lorca, offers the following definition of the querencia:

> "The querencia is the exact spot which every Spanish fighting bull chooses to return to, between his charges, in the arena. It is his invisible fortress,

> or camp...the nearer the bull is to his querencia, or stamping station, the more formidable he is, the more full of confidence, and the more difficult to lure abroad into the territory of the bullfighters..." (7)

When the treatment environment was divided according to the profession of the dominant performer in each of the 122 behavior settings, 11 querencias emerged which were labeled with the name of the professional group in charge. The querencias varied in number of settings, from Physician with 31 settings down to Recreational Therapist with 3 settings. Querencias also varied in the amount of time people spent within them, from Nurses, with more than 500,000 hours of occupancy per year, to Recreational Therapy with about 18,500 hours.

Ratings on 9-point scales were made of the characteristic activities in each of the behavior settings. The results of a factor analysis of these ratings indicated that these action patterns could be represented by a set of six orthogonal dimensions. Accordingly, factor score means were computed on each of the six activity dimensions for every querencia, permitting direct, quantitative comparisons between querencias on their characteristic activities.

Some illustrative results describing characteristic activities of certain querencias are summarized as follows:

1) Physicians control a querencia specialized in evaluation and treatment activities, to the virtual exclusion of social interaction and activities related to improvement in personal appearance.
2) The orthotist, or brace-maker querencia is specialized in activities related to evaluation and improvement in personal appearance.
3) Social service personnel control a querencia which is quite high in social interaction and personal appearance and correspondingly low in nutritive and evaluative activities.
4) The physical therapy querencia is very high in treatment activities, and close to the mean on all other activity dimensions.

These verbal descriptions give the flavor of the results obtained through a quantitative analysis of activity patterns. More detailed information is available elsewhere (8). In general, the data show quite distinct activity configurations for each of the querencias, suggesting that there is little redundancy or duplication of function between professional groups in the treatment environment.

Other ecological indices are possible in addition to those derived through the querencia classification. Two of these which may be the most interesting are discussed in the next section.

Ecological Measures of Visibility and Importance

The term, "dominant performer" has been used to designate leadership in a behavior setting. Similarly, at a more general level, the term, "performer," can be used to refer to anyone who carries out a task that is essential to the functioning of a behavior setting. Thus, in the doctor's office, the physician himself is in the position of a dominant performer. However, his secretary enacts an essential performance within the same behavior setting. Although the secretary has less control than the physician over the activities of the setting, she nevertheless can be counted as a performer. Thus, the total number of performances enacted by the members of each occupational group can be enumerated from behavior setting survey data. When they are expressed in relation to the total number of performances in the treatment environment, the resulting figure is termed the "Pied Piper Index" (5, p. 179). The Pied Piper Index is a measure of the hospital's loss if the group in question were to be piped away, or, alternatively, the number of performances that someone else would have to enact if the hospital were to maintain its level of functioning.

A related, but conceptually quite distinct question is raised when one considers the "visibility" of a given occupational group within the hospital. Rather than counting the number of important tasks performed by the group, visibility refers to the number of others present during these performances. Obviously, if role enactments occur in a small setting, the performer has less opportunity to be seen by others, even though the importance of his task may be great.

Data were collected on the issue of visibility by summing the total population of the settings in which a group performed and subtracting the members of the performing group. Thus, if a group performed in a setting composed largely of other members of the same occupational group, as in weekly staff meetings, the numbers of others present is far smaller than when a performance occurs before other hospital personnel or patients.

Table 2 presents data on ecological importance and visibility for a number of occupational groups within the hospital. These data have been refined by weighting them in accordance with the number of times a given setting occurred or was open for business during the survey year. The annual meeting of the hospital volunteers, for example, occurred only once whereas the nursing wards occurred 365 times during the survey year. Hence, the figures for average number of performers and for others present during a typical occurrence were multiplied by the total number of occurrences. For example, Line 1 in Table 2 indicates that physicians gave 21,985 performances during the twelve month period of the survey, in settings in which a total of 202,842 nonphysicians were present.

Table 2
Ecological Data on Functional Importance and Visibility of Selected Hospital Groups

Group	Pied Piper Index	Visibility
Physicians	21,985	202,842
Occupational Therapists	6,560	93,932
Physical Therapists	6,038	96,374
Nurses	20,007	190,757
Aides and Orderlies	42,020	122,955
Social Workers	11,639	154,597
Vocational Counselors	8,294	13,362
Administrative Personnel	19,403	167,659
Volunteers	7,372	140,762

The data in Table 2 indicates that physicians enacted slightly more than half of the number of performances during the survey year than did the aides and orderlies as a group, but physicians had far more visibility than any other group. Vocational counselors performed more times than three other groups, but had much less visibility, due to the number of these performances that occurred in small settings or with other vocational counselors present. The rank order correlation between these two indices is +.68, using data from all occupational groups, indicating a positive degree of association between the two indices, but the exceptions noted above seem quite impressive.

The Observed Patient Sample

The paper by Willems on this symposium describes the behavior characteristics of 12 patients with spinal cord injuries who were observed on comprehensive rehabilitation programs at TIRR during the summer of 1968. Data from the behavior setting survey can be used to describe the ecological habitat of the observed patient sample, and thus provides a contextual framework for the data from individual patients. The group of 19 settings inhabited by the observed patients has been described in detail in our earlier presentation to EDRA (9), and will be briefly summarized here.

The representativeness of the 12 patient days has been tested by comparing average occupancy time estimates in the 19 settings with similar estimates based on all patients from the behavior setting survey. The correlation between them was +.98, indicating that extremely comparable proportions of time were spent by the observed sample in comparison to patients in general.

Although the observed patients inhabited only 15 per cent of the total number of behavior settings in the treatment environment, the total amount of time spent by the inhabitants in these 19 settings accounts for the vast majority of the occupancy time in the patient sector. In other words, the observed patient sample were located at the center of the action in the treatment environment. The distribution of occupancy time is actually quite skewed across the 19 settings, with two separate wards accounting for more than 50 per cent of the total.

As might be expected from such enormous occupancy times, the settings inhabited by the observed patient sample are physically larger on the average and have a greater variety of staff in them than the typical setting inhabited by patients. However, as was pointed out in the discussion of frontstage and backstage sectors, aides and orderlies, and other groups with little training are overrepresented in the patient sector of the treatment environment.

Concluding Comments

This report has illustrated how ecological methods can be used to study behavior-environment relations in terms of precise, comparable and quantitative indices. The real pay-off of such methods, however, occurs when they are used in conjunction with data collection at the individual level, in order to focus on problems at the interface between behavior and environment. Individual behavior cannot adequately be retrieved from studying behavior settings, nor can environmental patterning be retrieved from studying the individual. In order to provide a complete picture of a complex, developmental phenomenon such as the rehabilitation process, data from both levels of analysis are needed.

Notes and References

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PLACE AND MOTIVATION: INDEPENDENCE AND COMPLEXITY IN PATIENT BEHAVIOR (1)

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Abstract

The rationale and procedures for the observational study of patients are presented. Analyses of data oriented toward the following issues are illustrated: (a) overall distribution of behaviors within hospital settings; (b) relations between locations and involvements by others; (c) location dependencies in specific behaviors; (d) underlying dimensions of behavior that can be used for comparisons among persons and settings; and (e) site specificity in the behavioral development of patients. The illustrations support the argument that observational procedures provide environmentally-oriented behavioral data that are not provided by any other techniques.

* * * * *

This paper illustrates some results of extensive, first-hand observations of patients. Before proceeding to the illustrations, a word is on order regarding the specific background and context of the study. Four ecological concerns provide that background.

First, progress in the environmentally-oriented behavioral sciences depends upon detailed, systematic observation that describes the distribution of phenomena in nature, *in situ*.

> "Every beginning textbook tells the student that failure and frustration are important behavior phenomena, and that rewards and punishments are important attributes of man's environment. But where is the information of the forms, abundance, and the distribution of these important phenomena outside the very limited, specially contrived situation of psychological laboratories and clinics? As a psychologist, what answer should I give a layman seeking information from me, as a scientific expert, on the occurrence among men of frustration, for example? To what handbook of data should I refer him (2, p. 52)?"
>
> "Because we have lacked such records, we have been able only to speculate about important questions. ...Before we can answer these kinds of questions, we must know more than the *laws* of behavior. We must know how the relevant conditions are distributed among men (3, pp. 2-3)."

This simple principle, so familiar to ecologists in other areas and to students of animal behavior, is just dawning effectively upon students of human behavior and its environment.

The second aspect is the importance of understanding the general, descriptive characteristics of a behavior-environment system before we analyze it and separate it into its subparts.

> "The distribution of animals is the end product of many interacting cause-effect systems, including behavioral systems. ...At first glance, the distribution of animals (and their behaviors)[4] in space and time appears unexciting, but upon closer examination this concrete measure reveals one of the most fundamental attributes of animals. The numbers and kinds of animals an ecosystem contains are the final result of all the behavioral, physiological, and biochemical mechanisms of each species interacting with other individuals, species, and the physical universe (5, p. 2)."

No other means but sustained observation and monitoring will provide the systematic descriptions of the behavioral systems whose mechanisms we need so badly to understand.

The third in this set of concerns is the discovery of specific congruences between behavior and environment, or the *site specificity* of behavior.

> "Although the localization of an organism in time and space may appear peripheral to the interests of the behaviorist, it can also indicate the behavior of the organism because feeding, drinking, resting, and other activities are often specific to a particular site. The correlations between site and activity is often so high that an experienced ecological psychologist can direct a person to a particular site in order to observe an animal exhibiting a given pattern of behavior (5, p. 4)."

It is just such insight into site and behavior that we are all seeking because we know that such linkages exist. Extensive observation is the single most effective means toward translating these beliefs into empirical reality.

Finally, and most specifically, a hospital patient's behavior is like a continuous stream that sometimes damps down to a minimal level and sometimes quickens to a very brisk pace, sometimes widens into several simultaneous occurrences and sometimes narrows down to one at a time, sometimes moves in isolation and sometimes intertwines with the behavior of others, sometimes changes form or direction at the patient's initiative and sometimes at the instigation of others. Each of the discrete events in that stream occurs at some unique place and time and yet the stream as a whole unfolds in a continuous manner over time. The interface between the patient's behavior stream and the hospital's delivery system is fundamental to the understanding of a hospital. The planners and the day-to-day agents of the hospital's delivery system assume that their environmental provisions are intimately intertwined with patient behavior; if this were not so there would be no reason to create systems of rehabilitative care.

Thus, our approach assumes that direct observation of patients not only provides a unique, systematic account of what patients do, but is very revealing of the workings of the hospital system itself and tells us much about patient-hospital relationships.

Method

Twenty-seven adults with lesions of the spinal cord have been observed--12 in 1968 and 15 in 1971--including all the spinal cord patients in the hospital's program of comprehensive rehabilitation at each time. Each group includes mixtures of ages, races, and sexes, and patients who varied from early in treatment to near discharge.

Each patient was observed continuously for one day, from 5:00 a.m. until 11:00 p.m., by a team of observers who rotated in two-hour shifts. Each observer watched his target patient and dictated observations of his behavior into a small, battery-operated cassette recorder. A series of systematic editing and clerical steps then yielded a set of 18-hour protocols representing on-the-spot descriptions of what patients did and enough of the context of their behavior to make it intelligible. In other words, we now have behavioral protocols totalling 486 hours of patient time, demarcated in terms of each minute of clock time, representing variability due to many sources, e.g., degree of progress, individual differences, locational differences, and differences in year of observation.

Our analysis assumes that each of the 27 protocols captures and describes the sequential behavior stream of a patient and that the events in that behavior stream include things the patient does, things that are done with him or to him, and periods during which the patient is idle or passive. The major coding unit, a chunk, codes a molar event in the behavior stream of a patient which (a) can be readily characterized by a single principle activity, (b) begins at a clearly described starting point, (c) occurs over time in a characteristic, sustained fashion, with all its essential accompaniments, and (d) ends at a clearly described stopping point. The analysis is designed to minimize the coder's inferential burden and to provide the means to retrieve systematic, quantitative information regarding the common, everyday behaviors of patients. Examples of chunks are: Watching TV, Eating a Scheduled Meal, Conversing with Physician, Passive Range of Motion Exercise on Arms, Waiting, Sleeping, Transferring, and Reading Magazine. For each chunk, a separate IBM card is prepared with nine categories of information including where the chunk occurred, in terms of behavior settings (see Dr. LeCompte's paper above); a descriptive label for the activity; how long it lasted; who else, if anyone, was directly involved in the principle activity; who instigated the chunk; and degree of involvement by the patient.

Independently of chunks, coders mark the occurrence of bits--fleeting social encounters or fleeting intrusions by others in the behavior streams of the patients, e.g., the fleeting query, "How are you?" by a passerby or the brief fluffing of a pillow by an orderly. Bits, which are clearly not patient behavior chunks, nevertheless represent an important part of the social environment. One kind, treatment bits, are oriented toward the patient's care, safety, comfort, or treatment. The second kind, sociable bits, include greetings, fleeting small talk, and other short, but purely sociable encounters. Each bit code is identified by where it occurred and who delivered it.

More complete procedural detail on our entire observational approach, including rationale and guidelines for observation, data reduction, coding, checks of reliability, and analysis are available elsewhere (6, 7, 8, 9). Data from 1971 are now being analyzed. Thus, the illustrations to follow are based on the data obtained from 12 patients in 1968. Application of the coding system to the 12 protocols yielded a total of 1815 chunks and the addition of the lengths of the chunks yielded a total of 14,227 chunk minutes. Chunk minutes total more than total running clock time (12,960 minutes) because two or more chunks sometimes overlapped when patients engaged in more than one major activity at once.

Place and Behavior: Some Illustrations

Table 1 displays the way in which the chunk minutes of the 12 patients distributed themselves across the various behavior settings of the hospital. These 20 settings (the 19 discussed by Dr. LeCompte plus Outside of Building) represent the patients' actual home range, or behavioral domain. Numbers in parentheses are the behavior setting numbers used by LeCompte. One or another of the patients entered and participated in 20 sites (19 settings and outside), but 69 per cent of their chunk minutes took place in the two ward settings (Stations 1-3 and Station 4). Furthermore, five settings--the two wards, physical therapy, hallways, and occupational therapy--enveloped almost 90 per cent of the chunk minutes, or behavioral time. In other words, about 90 per cent of the patients' behavior took place in only four per cent of the hospital's 122 settings.

Table 1
Distribution of Chunk Minutes by the Settings in Which They Occurred

	N (Min.)	% of total
(1) Stations 1-3	5082	35.7
(2) Station 4	4709	33.1
(10) General PT	1704	12.0
(13) General OT	749	5.3
(16) Recreational Therapy	403	2.8
(24) Hallways	395	2.8
(29) Cafeteria	348	2.4
(123) Outside	286	2.0
(112) Evening Recreation	194	1.4
(7) Dental Clinic	98	.7
(111) School Room	91	.6
(35) X-ray Lab	69	.5
(28) TV Area	39	.3
(27) Snack Area	31	.2
(12) Elect. Stimulation	8	.1
(49) Doctor's Office	8	.1
(20) Job Readiness Clinic	6	---
(22) Men's Restroom	5	---
(26) Korner Store	1	---
(40) Photography Lab	1	---
Total	14227	100.0

Table 2 displays the way in which bits, the fleeting interventions by others in the patients' behavior streams, were distributed by settings. The table excludes four settings in which only one chunk occurred and in which no bits occurred. Several things are clear. First, sociable bits occurred in more settings than treatment bits (1.25 as many). Second, the two ward settings captured over half of the sociable bits and over three-fourths of the treatment bits. Third, the first five settings (four per cent of the hospital's total) captured almost 90 per cent of the sociable bits and almost 95 per cent of the treatment bits. The data from Table 1 and Table 2 indicate that a small set of settings provides the context of most of the behavioral and experiential world of patients. Finally, what is already apparent--high correlations among the distributions of chunk minutes and bits by settings--indicate that if one knows the site, one can make very accurate predictions regarding a major share of patient behavior and experience.

Table 2
Distributions of Two Kinds of Bits by the Settings in Which They Occurred

	Sociable Bits		Treatment Bits	
	N	% of total	N	% of total
(1) Stations 1-3	279	31.1	313	46.6
(2) Station 4	192	21.4	202	30.1
(10) General PT	174	19.4	57	8.5
(24) Hallways	101	11.3	18	2.7
(13) General OT	57	6.4	43	6.4
(16) Rec. Therapy	30	3.3	7	1.0
(29) Cafeteria	18	2.0	11	1.6
(112) Evening Rec.	15	1.7	9	1.3
(123) Outside	14	1.6	6	.9
(27) Snack Area	7	.8	0	---
(7) Dental Clinic	3	.3	0	---
(111) School Room	2	.2	0	---
(35) X-ray Lab	2	.2	2	.3
(49) Doctor's Office	2	.2	1	.1
(20) Job Readiness	1	.1	0	---
(28) TV Area	0	---	2	.3

Table 3 illustrates how the data can be used to measure the extent to which various patient behaviors are location specific. Conversation, a very frequent behavior (occurring 2713 minutes in all), showed the least specialization, occurring in many settings. Sleeping, on the other hand, occurred only in the two wards. Exercise-and-Performance-Training and Nursing-Care-and-Hygiene ranged in between. The boundaries of the hospital's settings were most permeable to conversational behaviors and least permeable to sleeping. These data illustrate another approach to the study of site specificity. (Table 3 is on the following page.)

Involvement by Others

Comprehensive rehabilitation for severely disabled persons obviously involves much more than linkages between patient behavior and the hospital's physical system. Among the other important phenomena involved are ministrations, laying on of hands, and first-hand

Table 3
Four Types of Patient Behavior
and Their Distribution by Behavior Settings

	N	%
Conversing (2713 Chunk Min.)		
Stations 1-3	861	31.7
Station 4	828	30.5
General PT	317	11.7
General OT	242	8.9
Cafeteria	131	4.8
Recreational Therapy	108	4.0
Outside	105	3.9
Other	121	4.5
Exercise and Perf. Training (1570 Chunk Min.)		
General PT	1025	65.3
General OT	349	22.2
Station 4	123	7.8
Other	73	4.6
Nursing Care & Hygiene (1883 Chunk Min.)		
Station 4	1045	55.5
Stations 1-3	794	42.2
Other	44	4.6
Sleeping (1585 Chunk Min.)		
Stations 1-3	919	58.0
Station 4	666	42.0

involvements by members of the hospital family. Since each chunk is coded as to who else, if anyone, was directly involved in it, it is possible to retrieve a rather fine-grained picture of the persons through whom the hospital meets the patients. Furthermore, these involvements can be specified by location, so that the relationship between patient behavior and various combinations of places and other persons can be spelled out. Table 4 illustrates how this can be done with the observational data. Total chunk minutes of direct, behavioral involvement by several groups with target patients are shown by the settings in which they occurred. Aides and orderlies were heavily involved with patients. The involvements of aides and orderlies, other patients, and physicians were not very specialized as to location. It is especially interesting to note that the low overall rate of involvement by physicians (174 minutes) took them into a number of settings. Involvements by nurses, PTs, and OTs displayed much greater restriction by locations. It is possible to refine this picture further by taking account of what each group did with patients and where they did it to specify dependencies on location, type of person, and type of behavior in such involvements. Such data on who did what and where are of prime concern to the hospital in which we are doing our research.

Underlying Quantitative Structure

With a data domain as large as ours, we have devoted a good deal of attention to probing its underlying structure, using mainly correlational procedures and factor

Table 4
Per Cent Involvements by Six Groups, Distributed
Into Eight Behavior Settings

	Aides & Orderlies	Other Patients	Nurses	Physical Therapists	Occup. Therapists	MDs
Total Chunk Minutes Involved with Patients	3867	1296	1205	1110	995	174
(1) Stations 1-3	35.3*	22.1	33.1	----	----	27.6
(2) Station 4	37.8	41.0	57.0	----	----	17.2
(10) PT	11.8	9.0	----	98.0	----	8.6
(13) OT	----	----	----	----	64.4	----
(16) RT	5.7	6.5	----	----	30.4	----
(24) Hallways	3.9	----	----	----	----	----
(29) Cafeteria	----	9.3	----	----	----	15.5
(35)X-ray Lab	----	----	----	----	----	28.2

*Per cent of group's total involvement (row 1) spent in a particular setting.

analyses. Space permits only the barest illustration of this work. In one analysis, we used six categories of patient behavior considered to be singularly important by rehabilitation professionals: (a) the number of different kinds of behavior engaged in (behavioral richness); (b) the per cent of time spent in complete idleness or passivity; (c) the number of times that a patient did more than one thing at once (overlap); (d) the per cent of chunks instigated by patients themselves rather than someone else; (e) the per cent of chunks in which patients were actively and enthusiastically involved; and (f) the per cent of chunks that patients engaged in alone, without the direct involvement of anyone else. Each of these, in some way, represents an aspect of the patient's repertoire with which the rehabilitation system hopes to deal. These six categories of behavior were then considered in two ways: (a) as representing the 12 patients and (b) as representing 12 settings (seven settings of the 19 were eliminated because of extremely low frequencies of behavior).

Two principal components were extracted from each of the two intercorrelation matrices. In the data set representing patients, these two components accounted for 87 per cent of the variance. In the data set seen as representing settings, the two components accounted for 71 per cent of the variance. Then, each data set was subjected to a factor analysis, using Kaiser's Verimax Rotation Procedure to rotate the principal components toward simple structures. Each analysis yielded two orthogonal factors. In other words, beginning in two different ways (patients and settings), six critical behavioral variables reduced to two underlying dimensions in each case. There was an encouraging amount of similarity between corresponding factors from each of the two analyses, suggesting that a somewhat similar behavioral structure emerges whether we consider the behaviors to characterize persons or to characterize parts of the hospital. The most promising aspect of this result if that we are close to being able to use the same complex behavior patterns to compare patients with each other, to compare settings with each other, and to compare combinations of patients and settings with each other, all in terms that rehabilitative professionals consider meaningful.

For example, one factor emerged that we call independence because it involved the per cent of patient-instigated behavior and the per cent of time behavior was carried out alone; in other words, the rate at which patient behavior was under the control of the patient himself. The second factor we call complexity because it involved the per cent of time that patients did more than one thing at once. Independence and complexity are behavioral phenomena that the hospital wishes to enhance and we have been able to isolate them in quantitative, behavioral terms. Table 5 shows the loadings of the three behavioral categories on each of the two factors, for each of the two analyses. Much work remains to be done on such analyses, and we are pursuing them at present with the combined data for 1968 and 1971 (27 patients). Despite their tentativeness, the early results are suggestive enough to illustrate some further uses.

Table 5
Factor Loadings of Three Categories of Behavior in Two Factor Analyses

	Behaviors		
Factor Analyses	Overlapping	Patient Instigated	Behaving Alone
Patients			
Factor 1	.08	.91	.84
Factor 2	.98	.34	.20
Behavior Settings			
Factor 1	.06	.80	.93
Factor 2	.87	.37	.23

Behavioral Complexity

One of the behavior categories that emerged as a factor with some purety was the rate of behavioral overlapping, the frequency with which patients did more than one thing at once. We have found this to be a useful measure, as illustrated by two examples.

Table 6 shows differences in rate of behavioral complexity among four patients, all males, two of whom were early in their hospitalization and two of whom were near discharge.

Table 6
Summary of Overlapping for Four Patients

		Time	
	Instances of Overlap	Minutes of Overlap	% of Total Minutes
Early pts. (average)	23.5	77.75	7.6%
Advanced pts. (average)	51.5	180.00	16.7%
Advanced/Early	2.19	2.32	2.20

The first column records the number of times that behavioral chunks occurred in overlapping fashion, the second column shows the average number of minutes involved in overlapping behaviors, and the third column shows the proportion of overlapping minutes to total observational minutes. The ratios in the last line indicate that the behavior streams of the advanced patients marched along in complex, multiple patterns to a much higher degree than those of the early patients. These data indicate that the hospital is accomplishing an important part of its purpose. More importantly for present purposes, however, these results suggest that the complexity measure is a reliable indicator of a meaningful aspect of behavior. As such, they set the stage for the next illustration.

Out of the 12 patients observed in 1968, five could be classified as early and five as advanced. Table 7 displays the extent to which differences in behavioral complexity between early and advanced patients were dependent on locations in the hospital. In the two wards, complexity began (early patients) at a relatively low rate and remained there (advanced patients). In the two most central treatment settings (physical therapy and occupational therapy), complexity began at a low rate and grew to twice that amount for advanced patients. In the hallways, there was some change, but the overall rate of complexity was low. In other words, for behavioral complexity, a relatively pure factor in patient behavior, the rate of patient development was not generalized, but was quite specific as to sites.

Table 7
Rate of Complexity* for Early and Advanced Patients in Three Kinds of Settings

	Settings		
	Wards (2)	Treatment (2)	Hallways
Early Patients (N=5)	.23	.19	.05
Advanced Patients (N=5)	.23	.38	.09
Advanced/Early	1.00	2.00	1.80

*Proportion of instances of overlapping to total chunks.

Behavioral Independence

The second major behavioral factor was more complex, combining the rate of self-instigated behavior and the rate of behaving alone. We have found this combined measure of behavioral independence useful for a number of purposes.

First, as displayed in Table 8, we can measure variations among patients. In Table 8, each patient's rate of independence--minutes self-instigated and minutes behaving alone taken as an average proportion of total chunk minutes--is displayed for three formal settings combined: physical therapy, occupational therapy, and recreational therapy. Several things stand out. In these three settings, which lie at the heart of the rehabilitation program five patients exhibited little or no behavioral independence at all. More importantly, five out of the top six patients were near discharge, or almost ready to go home, while five out of the bottom six were early, or near admission. These data indicate that the two-part measure of independence signifies a meaningful aspect of behavior.

Table 8
Behavioral Independence Exhibited by Twelve Patients in Three Treatment Settings*

Patient No.	Index of Independence
2	.28
5	.20
6	.14
4	.12
11	.06
10	.04
3	.03
7	.005
12	.004
9	0.0
8	0.0
1	0.0

*Physical Therapy, Occupational Therapy, and Recreational Therapy.

Table 9 shows how the data from the 12 patients can be used to characterize behavior settings in terms of patient independence--a measure of location dependency in patient independence. Among the settings displayed, the two that are most public and most tangential to comprehensive rehabilitation--cafeteria and hallways--produced the most behavioral independence on the part of patients, while PT, OT, and RT--three settings at the heart of comprehensive rehabilitation--produced the least.

Since the results in Table 9 are based upon data from all 12 patients it is possible that the differences were produced by different patients who entered the settings at different rates. To test this alternative hypothesis, we calculated combined indices of independence for three settings (cafeteria, hallways, wards) and compared them to combined indices for a second set of three

Table 9
Characterization of Behavior Settings in Terms of Patient Independence

Setting	Rate of Patient Independence
Cafeteria	.64
Hallways	.48
Outside the Building	.30
Stations 1-3	.30
Station 4	.24
General OT	.15
General PT	.08
Recreational Therapy	.02

settings (OT, PT, RT) for each of the 12 patients. In the case of each patient, the results corroborated the patterns found above. For all 12 patients, the index of independence dropped as they moved from cafeteria-hallways-ward to OT-PT-RT. In fact, the index for one patient dropped from .42 to zero, despite the fact that she spent 172 chunk minutes in OT-PT-RT during her observational day.

Against the background of these location dependencies, Table 10 displays the extent to which differences between early and advanced patients are dependent on locations. These data suggest that behavioral independence began at a relatively low level in all three combinations of settings, but developed at sharply different rates. These cross-sectional comparisons (different patients at the two stages) suggest that while there was some development in the wards, there was somewhat more in the treatment settings and that there was phenomenal development in the hallways.

Table 10
Rate of Independence for Early and Advanced Patients in Three Kinds of Settings

	Settings		
	Wards (2)	Treatment (2)	Hallways
Early Patients (N=5)	.11	.04	.03
Advanced Patients (N=5)	.23	.14	.53
Advanced/Early	2.09	3.50	17.67

Data such as those illustrated in Tables 7 and 10 are especially intriguing to us because they converge on a very important issue. They point to site specificity of patient development, or site specificity in what the hospital considers its major long-range business. That is, change in the behavioral repertoires of patients over time is more dramatic in some settings than in others.

Concluding Comments

Direct observation of patients has yielded several classes of results that would not be available through any other techniques:

(1) High proportions of patient behavior and experience occur in a small proportion of settings. Behaviorally, the patient domain is relatively small.

(2) Involvements by others in patient behavior are highly dependent on locations. Some persons are location specialists and others are not.

(3) Patient behavior has a fairly coherent internal structure that can be made to correspond to the primary concerns of the rehabilitation professions.

(4) When we consider the most meaningful core of patient behavior, some of the smaller settings (in terms of patient participation) take on importance, e.g., cafeteria and hallways.

(5) Not only is there great site specificity of concrete behaviors by patients, but behavioral development itself is highly site specific and occurs most dramatically in some surprising places.

While we are intrigued by these results of the research, they are still only tentative. We are in the process of testing them further with the data gathered from 15 patients in 1971. Furthermore, all of our analyses of changes in behavior over time are cross-sectional, comparing different patients at different stages of progress. We are acutely aware of the need to test some of our hunches about site specificity in patient development in longitudinal fashion, using observations of the same patients at various stages. Such a study is now in the planning phase.

Notes and References

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CONTEXT AND CONSENSUS: THE DISTRIBUTION OF ROLE AGREEMENT (1)

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Abstract
Utilizing a multi-level concept of social organization, the study relates observational data on exposure time to verbal responses concerning occupational roles of the hospital staff. It was hypothesized that exposure of a respondent to an actor's role performances is positively associated with agreement between them regarding the actor's role. Positive correlations were found for four hospital groups, but inconsistent results occurred with three other groups. Patients identified roles on the basis of public or "frontstage" performances. Results are discussed in terms of role sets and the relevance of naturalistic methodology for the general theory of social organizations.

* * * * *

Hospitals, as one type of complex social organization, have received extensive theoretical and empirical attention by social scientists. This paper focuses on relationships between (1) the environmental structure of interaction, and (2) consensus on descriptions of selected roles by the various occupational groups and the spinal cord patients.

Two levels of data are utilized. The first set consists of a systematic description of the treatment environment of TIRR, as determined by the behavior setting survey (LeCompte, 2). The second derives from the role study (Vineberg & Levine, 3).

Data on general and specific exposure to role performances are related to consensus in a three-stage combinatorial analysis focusing on the interface between the two levels of data.

Method

Level 1: Survey of the Treatment Environment

The behavior setting survey characterizes the structure of social systems in terms of an ecology of behavior settings, or locations within which interaction takes place. The standing patterns of behavior within behavior settings are essentially recurring relationships between positions of the social system. The expectations and obligations governing these relationships between positions are the roles of the social system. Barker suggests that "...the settings, which are immediately circumjacent to episodes constitute the environment of roles, i.e., ...they are the ecological niches in which role behavior occurs (Barker, 4)."

The data from the behavior setting survey include the distribution of the different population groups within and among all of the settings. Distribution of groups within a setting includes the depth of penetration by members of each group into the control of the setting. Also recorded is the amount of time spent by the group members in each zone for a single occurrence of every setting.

Various concepts can be operationalized with these data. Dr. LeCompte has discussed occurrence, frontstage, backstage, and querencia. The latter term describes a non-overlapping territory for which a group carries the main performance.

Maximum possible exposure time of one group to another in the second group's querencia is defined as the smallest total amount of time that members of either of the groups spend in those settings making up that querencia. This is an indicator of the maximum amount of time the groups can be mutually present in those settings. For example, consider a setting inhabited by patients and physical therapists. If total patient occupancy time is 43 hours per occurrence, and total physical therapist occupancy time is 23 hours per occurrence, then maximum possible exposure time of patients to physical therapists in this setting is 23 hours.

Maximum possible exposure time of one group to another in some subset of settings, such as the querencia of a particular group, is defined as the sum of the maximum possible exposure times across the settings making up that subset. Dividing the maximum possible exposure time of a group within a particular querencia by the number of individuals in that group gives an additional index called the mean maximum possible exposure time of members of the group in that particular querencia.

Level 2: Data from the Network of Role Expectations

Construction of Common Categories

In order to make a comparison of the extent to which occupational groups were described in a similar fashion, a common category scheme was contructed from the role data. All of the original category headings (indicating the "theme" of the responses contained within the category) were placed on 3 X 5 cards and identified as to target group. These cards were shuffled and sorted into stacks containing all category labels with the same general theme. Fifteen common categories were constructed from this collapsing of the original categories. Fourteen of these contained substantive information, and the fifteenth contained responses which could not be placed in any other of the collapsed categories. Descriptive titles for the fourteen common categories are displayed in Table 1. Most of the responses in Category 15 referred to the role of the volunteers (58%), who were not included in this study.

Table 1
Labels for Common Categories

Category	Label
1	Outside Liaison. Acting as liaison for patients with the world outside the hospital.
2	Giving Assistance. Doing everyday kinds of things for the patient he cannot do for himself.
3	Mediation. Mediating between groups in the hospital.
4	Evaluation and Diagnoses.
5	Supervisory.
6	Working as a Team Member.
7	Nursing Care.
8	Specific Physical Rehabilitative Activity.
9	Resocialization.
10	Boredom Relief. Making patients' lives more pleasant.
11	Teaching and Research.
12	Administrative. Inside liaison.
13	Secondary Services. Activities which, if discontinued, would not affect the overall functioning of the hospital.
14	Justification. Reference to characteristics groups have by virtue of their specific training.
15	Miscellaneous.

Combinatorial Analyses of the Two Levels of Description

The main thrust of this paper is to combine data from the interview study and behavior setting survey. Meanings implicit in social organization are viewed as mediated by actors through their performance in roles and thus greater exposure of one actor to the role performance of other actors should lead to higher agreement between them.

Ecological data from the behavior setting survey are used to specify antecedent conditions which predict variation in agreement about occupational roles.

Three basic analyses of these data are reported. First, the overall distribution of agreement between respondents and targets on role descriptions is described. These figures are independent of any controls for amount or type of exposure to the target groups. The second analyses investigates the differences in role descriptions as related to the amount of exposure of respondents to the role performances of target groups. The third analysis investigates the degree of consensus as a function of the specific performances observed by the patients as one respondent group.

Results

Analysis 1: General Agreement on Occupational Roles

Pearson product-moment correlations were computed separately for each of the nine respondent groups across each of the seven target groups, producing a total number of 63 measures of association. In this computation, the actual proportion of responses in categories constituted the raw data.

To facilitate comparison, the correlations were averaged through use of Z-score transformations for each target group. The resulting mean correlation and rank of the seven multi-member target groups is shown in Table 2.

Table 2
Average Correlations of Multiple Member Respondent Groups with Each Multiple Member Target Group, According to Number of Responses in Common Categories

Target Group	Rank	Avg. r	Range of r
Physical Therapists (PT)	1	.98	.96 - .99
Occupational Therapists (OT)	2	.97	.69 - .99
Physicians (MD)	3	.88	.80 - .96
Nurses (RN)	4	.84	.68 - .95
Aides/Orderlies (A/O)	5	.80	.36 - .98
Social Workers (SW)	6	.54	.27 - .76
Vocational Counselors (VC)	7	.43	.18 - .55

Note: The present table utilizes data only from groups with more than one member.

The data in Table 2 show quite high general agreement among respondents on role descriptions for five target groups. The wide variation in the range of the correlations of these five groups indicates differences in extent or "tightness" of this general agreement for the various groups. The average correlations for the two remaining groups, social workers and vocational counselors, show considerably less general agreement among respondents.

Analysis 2: The Exposure Time-Consensus Relationship

One important antecedent condition of consensus between actors in a social system was hypothesized to be the amount of exposure of one actor to the role performance of the others. In the present investigation, exposure has been defined ecologically as the amount of time spent by respondent groups as members of the role set of the target groups. Thus, it was possible to retrieve from the behavior setting data the average maximum exposure time of every respondent group in the querencia of each target group.

Table 3 shows each of the groups as a target position, the other groups which form the role set within the querencia of the target group, and the average maximum exposure hours per year individual respondents are exposed to the target position in his querencia (5).

Table 3
Respondents' Average Maximum Exposure Hours Per Year in the Querencia of Target Groups

Target Groups[a]	Respondent Groups (Role Set Members)							
	OT	MD	SW	PT	RN	VC	A/O	Patients
OT	------	20.00	10.00	3.84	1.38	0.00	93.55	152.06
MD	130.33	------	458.00	90.15	793.20	117.50	11.55	76.08
SW	0.16	0.40	------	0.23	.69	.50	0.00	31.98
PT	0.00	105.00	105.00	------	2.08	0.00	163.88	150.10
RN	41.50	29.50	115.60	8.38	------	0.00	324.11	166.32
VC[b]	0.00	0.00	30.00	0.00	0.00	------	0.00	72.50
Totals	171.99	154.90	718.60	102.60	797.35	118.00	593.09	649.04

Note: Occupational Group symbols are explicated in Table 4.
[a] Querencia of Groups as Focal Positions. A/O did not have a querencia.
[b] Vocational Counselors are virtually an autonomous group dealing with outpatients rather than inpatients.

In Table 3, the mean maximum possible exposure hours of each respondent in the querencia of each target group for the survey year is depicted within the columns.

Table 4 shows the Pearson correlation between the average maximum exposure hours per year of respondents to target groups and the Z-score transformations of Pearson correlations between target groups and respondent groups on the role of target groups. Looking at Table 4 we can see that there is virtually no correlation between the exposure of occupational therapists and social workers as members of the role sets of target groups and their agreement with those same targets about the target role. There is some positive correlation between these two indices for nurses and patients. Doctors and aides and orderlies, the two groups for whom there is moderately high correlation, are interestingly enough the two groups who have, respectively, the most and least formal training. Physical therapists have a low negative correlation between the exposure and agreement indices. Physical therapists also have the lowest total time as role set members in the querencia of other groups.

Table 4
Correlations Between Exposure Time to Others
and Agreement for Each Respondent Group

Respondent Groups						
OT	MD	SW	PT	RN	A/O	Patient
.06	.61	.01	-.28	.11	.75	.57

Analysis 3: Analysis of Patient Agreement and Exposure Time

The third analysis of the data involves specification of particular target group performances observed by patients as occupants of one position in the role set of those target groups. This specification should lend some light to the descriptions which patients gave of those target groups.

The patients, as members of the role set of the target groups, enter into some aspects and observe other aspects of the performances of target groups in their querencia. However, the scope of the patients' involvement and observation is limited by environmental structuring (in terms of behavior settings) of these observations and interactions.

Table 5 shows the patients' overall distribution of responses in the categories and thus their general impressions of the activities within the hospital. The responses are most heavily concentrated in those categories referring to direct care, with the highest percentage in Category 8 indicating an emphasis on activities related to the actual physical rehabilitation of the patients. Two other categories, 2 (giving assistance), and 7 (specific nursing care), each contain 12 per cent of the responses. Three other categories contain 8 per cent of the responses each. These are Category 4 (evaluation and diagnoses), Category 5 (supervision of the care process) and Category 10 (referring to making the patients' stay easier and to boredom relief).

Table 5
Overall Distribution of Patients' Responses in Common Categories[a]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Number of Responses															
	24	51	6	34	34	25	50	96	30	33	11	16	0	18	428
Percent of Responses															
	6	12	0	8	8	6	12	22	7	8	3	4	0	4	100

[a] See Table 1 for explanation of categories.

In general then, the descriptions given by patients of the roles of these occupational groups are concerned with aspects of actual hospital service such as physical rehabilitation activities, nursing care and assistive activities. On the other hand, only a little over 7 per cent of the patients' responses indicate an awareness of activities not directly related to treatment, which serve to keep the hospital operating as a going concern. Ninety-one per cent of the patients' time is spent in four settings: occupational therapy, physical therapy, and two different wards. (Approximately 78% is spent in the wards).

Discussion

One source of these agreement figures was hypothesized to be the amount of exposure respondents had as role set members to the various targets' role performance. The data from this second inquiry indicate that many of the respondent groups had little to no such exposure in the querencia of some target groups. The correlations which were computed did not indicate a simple relationship between this measure of exposure and agreement.

Formal education does not explain the relationships. The group with the most formal education, MD, and the group with the least formal education, A/O, have the highest relationship between exposure and agreement. One of the groups with high education, SW, has a low agreement-exposure relationship. Another variable, territorial range, as discussed by Dr. LeCompte, characterizes the variety of experience of the different groups. The three groups who had the highest territorial range (MD, A/O and RN), also had the highest agreement-exposure correlations, while the three groups with the lowest territorial range (PT, OT, and SW) had the lowest agreement-exposure correlations. This suggests a number of things. First, that segmental exposure to another position does not necessarily lead to greater knowledge of the scope of that position. Second, that a greater variety of exposure, even if not for an extensive amount of time, increases knowledge of the scope of other roles. Third, that increased variety of exposure can increase knowledge of the scope of other positions and may have the same effect in this respect as does higher education training.

Finally, the patients' experience of the hospital was seen to be highly concentrated in four of 76 treatment settings. In these settings, the patients are seldom exposed to or interact with the occupational groups while those groups are engaged in activity other than direct delivery of services.

A major portion of sociological research involving formal organizations has emphasized the study of bureaucratic authority structures. When applied to hospitals, the analysis typically demonstrates the degree to which the hospital deviates from the more ideal form of such authority structure. This paper has begun an exploration of other dimensions of social organization through the application of an ecological methodology. The data from this approach begins to tap directly the interaction occurring within the physical boundaries of the organization.

Notes and Footnotes

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Medicine. The author is grateful to Shalom E. Vineberg, Edwin P. Willems, William F. LeCompte, and Anson J. Levine for making available parts of the data used in the present report. Special appreciation is extended to Sol Tannenbaum for critical comments on an earlier version.

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5. Maximum exposure hours per person was computed by dividing the total yearly exposure time of a group by the number of persons in that group.

BEHAVIOR-ENVIRONMENT CONGRUENCE: A MODEL OF BEHAVIORAL ECOLOGY

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My role at this symposium is to comment upon the preceding presentations, and to relate them to the general problem area of *behavior-environment congruence*. It has not been possible to review the other papers before the publication deadline. However, interested readers may wish to refer to Wicker (1972); the paper attempts to relate a number of psychological theories to the question, "What events occur in naturally-occurring settings to assure that the behaviors of setting occupants are within the range acceptable to other occupants and congruent with the physical features of the setting?"

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5: THE ENVIRONMENTAL BEHAVIOR OF CHILDREN

ENVIRONMENTS FOR THE DEVELOPING CHILD

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Each week some new, glossy covered, paperback cries out from the bookstore shelves a popular restatement of the need for a more child-oriented approach to education. The major point is similar to that recognized forty years ago by Dewey and a century before by Froebel: a child develops cognitively, socially, and emotionally through his own interaction with the total environment. Widespread acceptance of this notion of child as an active learner among teachers and parents is still awaited, although the idea is well recognized by a large number of contemporary educational theorists (1) developmental psychologists (2) and a growing number of teachers.

As an important part of the total environment, the designed environment can have an influence on the kinds of child-environment interactions which occur. In this regard, the physical environment does not demand behavior of a certain kind, but is nevertheless "permissive, supportive, or resistive" (3). Unfortunately, there have been very few attempts to relate contemporary educational philosophy to design for children (4). We need to know how to create physical environments which allow for the kinds of child-environment interactions which our particular educational philosophy tells us leads to the development of rich and competent human beings. We may anticipate that there is no single approach to be used at the exclusion of all others, but we may be sure that whatever procedure is adopted, it must include improvement in communication between designer, practitioner, and user, if it is to be successful.

The problem is multi-faceted. Consider for example the contemporary state of affairs. We are presently witnessing in the United States, an example of building design technology blindly leading the way in the creation of learning environments. A plethora of "open space" schools are being created in response to faddism with little relation to the "open education" movement with which they are commonly identified. The term "open space" is applied to school building with no interior walls (5), whereas "open education" refers to an approach to education which offers more freedom to children by recognizing their need to actively engage with the environment and structure their own experiences (6). While there are indications that the early open space schools came partly in response to the open education movement and its need for more "flexible" spaces (7), so quickly and naively had this process taken place that designers, parents, and even teachers confuse open space with open education, revealing either their ignorance of the distinction, or a belief in deterministic design which can magically produce a new education. And as we observe confused teachers in open space schools knowing nothing of the goals of the designer, recreating walls and modifying these open spaces, we see an example of the problem: poor communication between educational practitioners and educational designers.

Behavioral research has much to offer in facilitating communication between designers, educational philosophers (including parents), teachers, and children, through the observation of child-environment interactions. But greater changes are required: if we are to honestly recognize contemporary educational theory, design itself must become part of the interactive process. Because education is a continuing developmental process, we can no longer speak of once-and-for-all design solutions; we must radically alter our notion of the role of the designer. Both behavioral scientists and designers must expect to return frequently not only as "doctor" and "surgeon" diagnosing and treating poor fit, but also as part of a continuing team creating with teachers and children environments which encourage child development. Although such suggestions are presently largely impractical due to institutional barriers, the growing community involvement in education and increasing community demands for control in the running of their own educational facilities points to an exciting potential for the creation of more relevant learning environments. Naturalistic observational research into the environmental behavior of children can play a most direct role in this movement. Such research can tell teachers and parents simply what child-environment interactions are taking place, where, and at what time. In this way, the educational philosophy of the community can be better related to the designed environment through suitable design modification. It is not suggested that this is the only useful approach in the application of environmental behavior research to design -- on the contrary, for this is the subject of a healthy difference of opinion (8) However, we know so little of the complexity of human behavior in relation to the physical environment that the evaluation of specific environments in relation to the goals of particular educational philosophies seems presently more within our capacity than the identification of universal behavioral requirements and design specifications. It has been possible so far to suggest optimal specifications for such technical factors as acoustics, lighting, and ventilation, etc., but we are far from ready to do the same with environmental behavior and environmental learning.

In addition to the immediate need for applied behavioral research in the design of specific environments, there is a need for pure research on the environmental behavior of children. We need to look at the influence of the everyday physical environment on the cognitive, social and affective behavior of the child. Much of the excellent psychological research on cognitive development may be extended and brought closer to the everyday experiences of children (9). Research on the influence of the physical environment on children's social interaction has already demonstrated its potential relevance to the design of children's environments (10), but there is a need for more systematic research in this field. Even less is known of the relation between the physical environment and the child's affective behavior (11). The complexity of the field of environmental behavior and our limited knowledge across the domains of child development is well exemplified by looking more broadly than usual at the popular notion of the value a stimulus-rich, complex, changing environment has for the child. While there is evidence that stimulus complexity and novelty plays a role in cognitive development by stimulating curiosity and exploration (12), the influence of environmental complexity and change on the child's affective and social behavior is little understood. It may be that a component of a child's urge for security is a strong affective attachment to certain places or parts of the physical environment, calling for environmental stability rather than change. Furthermore, attachment to that place or part of the physical environment may be related to certain social properties it may have such as an important meeting place or a place of common value to a group. In short, physical change may influence emotional and social as well as cognitive development. Such meager knowledge of children's relations to the physical environment is not only a function of the complexity of the problem, but also of the past emphasis in American psychology on organismic and social variables in human behavior. The field of environmental behavior is challenged to respond to such general questions through pure research, as well as to the specific questions of applied research which are of more immediate relevance to the design profession.
In the workshop on Environments for the Developing Child and the session on the Environmental Behavior of Children we are concerned more with applied than with pure research.

Workshop on the Design of Environments for the Developing Child

A special Workshop has been arranged for the weekend preceeding the EDRA conference. A small but widely ranging and experienced group of designers, educators and behavioral scientists hope to provide directions for tackling the problem of creating more relevant learning environments for children. Applications to the fields of education, design, and behavioral research will be recorded by Solomon, Moore, and Hart, while Ellen Perry Berkeley will prepare a report of the entire session for distribution to the conference-at-large.
The workshop will begin with a discussion of the range of alternative educational theories and their implications for research and design. We anticipate discussion of not only the open education concept (13), but also ideas of the city as a learning environment (14) community involvement (15), and playgrounds as learning environments (16). However, the most immediate concern in the United States seems to be what to do with existing school facilities, open plan or otherwise, to bring them more into line with the open education concept. The workshop will therefore focus on how to relate this philosophy to design.

Session on the Environmental Behavior of Children

The following research presentations serve as background papers for the workshop. They demonstrate that research in environmental behavior has an important role to play in the design of more suitable environments for children, and illustrate some of the methodologies available. Unfortunately, the research is limited largely to pre-school and elementary school children in meso- or architectual scale environments. There is presently little work being undertaken of any quality at the macro or planning scale of environment. We recognize that by limiting the workshop to the micro scale we would not be addressing ourselves to the breadth of contemporary ideas in the field of education. Nevertheless, the research which follows is particularly relevant to the workshop because of widespread belief in some kind of school building for the education of children.

In reporting the work of the Motor Performance and Play Research Laboratory, Ellis illustrates the complexity of environmental behavior and the need for caution in the application of findings. His statements on play are particularly valuable, however, in explaining the child's active engagement of the environment outside as well as inside school buildings as a crucial part of development. Shaw and Robertson suggest how such knowledge may be utilized in design for children with a film presentation of their experimental playgrounds.

Research utilizing both naturalistic and experimental approaches to the observation of child-environment interactions are reported. Each approach has its particular merits: the naturalistic approach has obvious value as a means of discovering through observation whether or not certain behaviors are occurring in a specific environment. The experimental approach attempts to identify the effects of particular design elements; it offers control and experimental rigor but is of less immediate value to designers. Durlak, Beardsley and Murray present a comprehensive,comparative observational study of behavior in traditional, open, and flexible planned schools which is of particular relevance to the workshop. In contrast, Bartholomew and Potts offer an example of the use of a test environment in measuring experimentally the influence of particular variables of the physical environment on behavior. The paper by Wolfe and Rivlin is concerned with a more specific population: emotionally disturbed children. The research approach is, however, of particular relevance to the workshop. By studying the development of usage patterns of children in a new psychiatric hospital,Wolfe and Rivlin have truly recognized a child's environmental behavior to be a continual process of interaction and adjustment. This approach provides a model for the research which must take place if we are to design with change in mind.

The above research presentations are examples of the kinds of behavioral research available to us. They do not, however, answer directly the problem of communication between client, user, and designer. Cohen, a psychiatrist who has been working in Columbia, Maryland, on the creation of children's playgrounds, believes improved communication is crucial, and in a film presentation will elaborate upon his group process approach to the design of children's playgrounds. His work demonstrates vividly that behavioral data is useless if you cannot communicate its relevance to others.

Notes

1. In a background review paper for the Workshop on Environments for the Developing Child entitled Open Education, Lynn Simek distinguishes between two types of contemporary educators: the more pragmatic group, dealing with the situation in the classroom, and those who see educational problems as social imperatives. Some examples of the first group are:

   Coles, R., Children of Crisis, Boston: Little Brown, 1967.

   Dennison, G., Lives of Children, New York: Random House, 1969.

   Kohl, H., The Open Classroom, New York: Vintage, 1970.

   Holt, J., How Children Fail, New York: Dell, 1966.

   Hentoff, N., Our Children are Dying, New York: Viking, 1966.

   Some examples of the second group are:

   Goodman, P., Growing Up Absurd, New York: Harper and Row, 1971.

   Illich, I., Deschooling Society, New York: Harper and Row, 1971.

   Kozol, J., Death at an Early Age, New York: Bantam, 1967.

   Silverman, C., Crisis in the Classroom, New York: Random House, 1960.

2. Psychologists who have been particularly influential in this regard are Jean Piaget, Jerome Bruner, and Maria Montesorri. As introductions see:

   Piaget, J., Six Psychological Studies, New York: Random House, 1967.

Bruner, J., The Process of Education, New York: Random House, 1960.

Montessori, M., Spontaneous Activity in Education. New York: Schoken Books, 1965.

3. Baxter, R.G., On the Nature of the Environment. Journal of Social Issues, 1963, 19, 17-38.

4. One attempt to initiate greater collaboration between architecture and contemporary education through a collection of insightful papers is particularly worthy of note: Architecture and Education, Harvard Educational Review, 1969, 39, 1-147.

5. Educational Facilities Laboratory, Profiles of Significant Schools: Schools Without Walls. New York: Educational Facilities Laboratory, 1965.

Stanford Planning Laboratory, Open-Space Schools Project Bulletin, No. 1, issued by School Planning Laboratory, School of Education, Stanford University, 1970.

6. See note 1, preceeding page.

7. See Educational Facilities Laboratory report - Note 5, above.

8. For a number of different approaches see: H. Proshansky, W.S. Ittleson, & L. Rivlin (Eds.), Environmental Psychology: Man and His Physical Setting, New York: Holt, Rinehart and Winston, 1967, Part One - Theoretical Conceptions and Approaches.

9. For example: Hart, R.A. and Moore, G.T., The Development of Spatial Cognition: A Review. R. Downs and D. Stea (Eds.), Cognitive Mapping Images of Spatial Environments, Chicago: Aldine-Atherton (in press). This is an attempt to relate fundamental theories on the development of spatial cognition to cognition of the everyday physical environment.

10. As an introduction see: Sommer, R., Personal Space: The Behavioral Basis of Design, Englewood Cliffs, N.J.: Prentice Hall, 1969.

11. For a fresh look at the childs' relation to the physical environment which recognizes affectivity see: Cobb, E., The Ecology of Imagination in Childhood, Daedalus, 1959, 88, 537-548.

12. Reviewed by: Fowler, H., Curiosity and Exploratory Behavior, New York: Macmillan, 1956.

13. See note 1, preceeding page.

14. Carr, S. and Lynch, K., Where Learning Happens, Daedalus, Summer, 1968, 1277-1291.

Woods, S., The Education Bazaar, Harvard Educational Review: Architecture and Education, 1969, 39, No. 4, 116-125.

De Carlo, G., Why/How to Build School Buildings, Harvard Educational Review: Architecture and Education, 1969, 39, No. 6, 12-35.

15. Blackman, A., Friedus, K., Robinson, D. and Ladd, F.S., Interview with Topper Carew. Harvard Educational Review: Architecture and Education, 1969, 39, No. 4, 98-115.

16. Jacobs, J., The Use of Sidewalks: Assimilating Children. Proshansky, H.M., Ittleson, W.H. and Rivlin, L.G. (Eds.), Environmental Psychology: Man and His Physical Setting, New York: Holt, Rinehart and Winston, 1967.

Morton, D.A., Playing to Learn. Progressive Architecture, 1970, 51, No.11, 80-83.

EVOLUTION OF SPACE UTILIZATION PATTERNS IN A CHILDREN'S PSYCHIATRIC HOSPITAL

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Abstract

This study focused on the relationship between the physical environment of a new psychiatric hospital and the activity patterns of disturbed children. We dealt with two interrelated issues --the development of use patterns, their stability and change over time and the relationship between these patterns and the administrative philosophy and events in the life history of a building. Using the behavioral mapping technique, we assessed the use of space at three times-- the first two weeks of occupancy, two and four months later. Data were supplemented by staff interviews, patient demographics and records on treatment philosophy and use of space. Results indicate: 1) that the evolution of space utilization patterns can be demonstrated 2) these patterns evolve from the earliest days of occupancy creating an atmosphere for the hospital and 3) they reflect not only the physical design of the building but also the ongoing events in the building's life history. Our data underline the importance of considering the physical setting and the administrative and therapeutic philosophy as interactive factors in the development of space utilization patterns.

Introduction

The physical setting of a psychiatric hospital represents one of the more fixed elements in the therapeutic environment. Its contribution is set, in large measure, when the facility is completed. Yet the current emphasis on milieu therapy considers the physical setting as a participant in the treatment process. In fact, psychiatric buildings long have functioned as part of the therapy (or lack of it) offered to patients. The very from of a building communicates to the occupants whether they are in a prison, a retreat, a place to recover or an educational setting.

Although therapeutic philosophies are rarely set or explicit during the design stage of a hospital, both architects and administrators know that skillful use of space can facilitate the goals of an institution. Details of how this can be accomplished now rest more on intuition than on empirical data. Limited concrete information is available. Bayes (1) has reviewed information which is largely speculative. Berensen (2) is one of the few investigators who have dealt experimentally with this problem. More common are general reviews with planning programs built on accumulated experience (3), (4), (5), or descriptions of the hospital, with limited specific reference to an explicit use of the physical setting (6), (7), (8). The pressing need is for closer attention to what happens in existing hospital forms, and some understanding of the complex interrelationship of a building and its occupants.

The study reported in this paper is an attempt to provide an empirical base to some of the generalizations about the relationship between space and behavior in a childrens' psychiatric hospital. In particular, the work centers on the questions of how space utilization patterns are set, how they develop, and whether they change over time. Previous work in psychiatric hospitals has studied space and behavior long after use patterns have been established. Yet we have felt that the early stage of the occupancy of a building is a critical period. It would appear that a longitudinal approach is essential in unraveling the process of space use, that is, a study of space utilization patterns from their inception and over time. The life history of the use of a building can reveal expected and unexpected effects of the building on occupants, as well as changes, (both structural and functional), that were never part of the original designs. The early days in the life of a building, when patterns of use are being established involve critical, irreversible decisions regarding function, and these set up the available options for future occupants. This may help explain the stability of certain observed patterns of use over time and across users, a theme that has repeated itself in many of our earlier studies (9), (10). Clearly, though, one can never know how early use influences later behavior, unless it is the central theme of a study.

Although the focus on man and his physical setting represents a renewed interest, in recent years, with basic theory still in its early stages, some understanding of the spatial learning process is helpful in placing empirical data into a framework. In our work, we tend to view the process of spatial learning as a function of the number and types of choices available to individuals in a particular setting. Although such factors as personality, past life history, past environmental experiences all act to influence a person's behavior in a given setting, the array of possibilities for action in a given environment is also important, and this array is in part a result of the physical aspects of the setting and in part a function of implicit and explicit rules of use, that develop over time. Thus, the decisions of the initial occupancy period act to either expand, or more often reduce the options of later occupants. Bedrooms, institutionalized as private retreats may never function as social areas, however much pressure is later exerted for a broader use. A dayroom carefully arranged by the housekeeping staff to facilitate caretaking may never acquire the flexibility necessary for patients to use it as a living space. Hidden too, in the first period of occupancy are many problems, some expected, others unexpected, but all leading to early decisions about the use of facilities that may be forgotten in later years. We have found repeated examples, buried in the life history of buildings, of uses that continue, despite the fact that their rationale is unclear.

When considered in terms of the life of a child, the physical environment may assume even more prominent a role than in the case of adults. This is particularly true in the case of children with psychiatric problems severe enough to require hospitalization. For the child, with an incomplete sense of himself as unique and separate from the outside, the use of space and his conception of the physical world are more direct expressions of his level of ego development than would be true for adults. In the disturbed child, the process of differentiation from the physical world is likely to be exaggerated with space and objects, in space often taking in qualities of the significant people in that setting (11), (12).

Although children's use of physical space, per se, has not been studied extensively, there is growing research documenting the specific qualities of an environment that are likely to affect the children within it. Hutt (13) and Hutt and Vaizey (14) have studied density and social behavior, indicating the increase in aggressive and destructive behavior in normal and brain-damaged children, as density increased. Interestingly for autistic children, already within their own world, less aggressive behavior was observed under denser conditions although it resulted in greater use of the edges of the room and greater need for supportive interaction with adults. These studies are especially important to the present work since they underline the general principle that hospitalized children are vulnerable to events in their immediate physical setting, and also, that the numbers of people in a setting are especially critical to the behavior of children, a theme to which we will return, when reviewing the results of our studies.

For the hospitalized child, whose day is largely directed by adults, the options available in the physical setting are potentially more limited than would be true for an adult. In a sense, this places a greater burden on the design of the building, for freedom of choice will be only in part, a product of what the child would like to do - in greater measure a function of what the staff permits him to do.

Our focus, then, is directed to two interrelated issues -- the story of the development of use patterns, their stability and change over time, and the relationship between these patterns and the administrative philosophy and events in the life of a building.

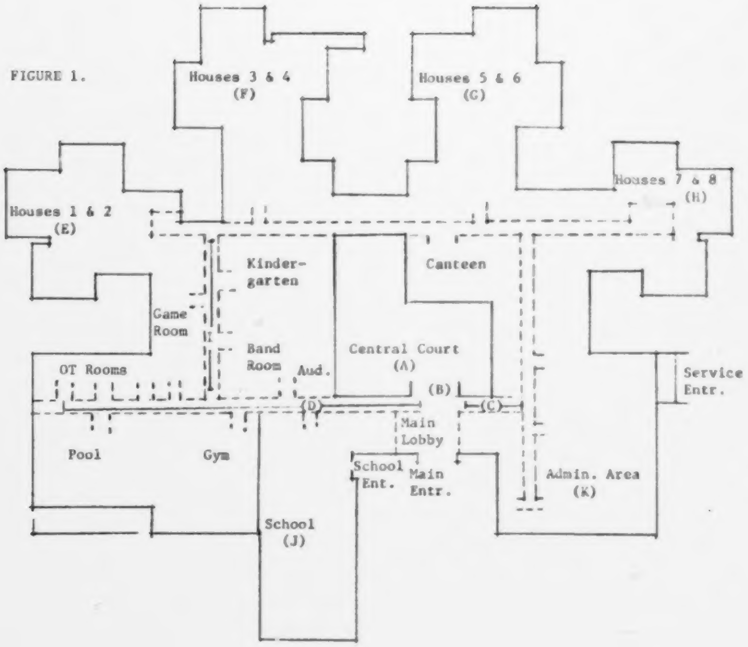
Description of the Children's Psychiatric Hospital

The children's psychiatric hospital, where the present research was conducted, is a state psychiatric facility designed to provide inpatient psychiatric care for 192 children ranging in age from 5 to 15. There are residence facilities, a school, and areas for occupational therapy, recreation, diagnostics and treatment. It is located on a large tract of land which also contains a large state psychiatric facility for adults. A visitor to the children's hospital must pass through a rather winding road leading to a number of high rise buildings belonging to the adult hospital. The irregular roofs of the children's hospital are in marked contrast to other structures in the setting.

The building (Figure 1, see page 5-2-3) is organized around a central open space (A). The primary circulation route rings the court and the various functions of the building radiate from it. There are four major areas in the building: 1) living; 2) recreational and community; 3) school; and 4) administrative. The building is two stories high, and other than the infirmary, no area is more than a half level from the main floor.

Walking in the main entrance, one finds a high-ceilinged lobby with couches and chairs, some telephone booths, and the receptionist's desk. Facing the entrance, to the rear of the lobby are glass doors leading to the central court (Figure 1,B). Extending on either side of the lobby is a long corridor. The right corridor (Figure 1,C) leads to the administrative areas, the left corridor (Figure 1,D) goes to the recreational, school and living areas. The living areas or "houses" (Figure 1, E,F,G,H) are farthest from the lobby and are reached by a walk through the corridors and around the building. The eight-foot corridors appear rather long despite the fact that they are relieved at intervals by glass sections along the central space. Windows at the rear of the building

FIGURE 1.



offer a view of the outside play areas.

There are eight "houses" or ward units, each designed for 24 children, arranged in four sets of two "houses" each, one "house" above the other (1/2 floor above and 1/2 floor below the main level). The 48 children from each set of houses share a common dining room on the main floor. There are no facilities for food preparation. Food is prepared in the adult psychiatric hospital and transported via a tunnel to the children's hospital building.

Six of the eight houses are identical in design (Houses 2,3,4,5,6,8) and each contains a total of 24 defined rooms. There is a center corridor leading to three 8-person units or apartments, a communal day room with kitchenette, a nurses' station, a laundry room, an office and various storage facilities. Each 8-person living unit has a small entry foyer with a bathroom, a living room and 4 bedrooms located around the living room. There are 2 single-bed rooms, one 2-bedded room, and a 4-bedded room. The bedrooms have no doors. Two houses (House 1 and 7) were originally designed to house autistic children. These houses have the same amount of floor space and the same basic design as the other six houses. However, only two rooms within each 8-person living unit were defined by walls: a large room designed to serve as sleeping quarters for six children as well as the living room for all eight children, and one two-bedded room.

The furniture for the living units was either designed or selected by the architect. The beds have a storage unit which can be attached at the head or used separately. These beds are not on rollers but are light enough to be moved easily. The living room furniture includes multi-use ottomans and benches. The floors are covered with indoor-outdoor carpet. There is liberal use of glass throughout the hospital. Each bedroom has windows and the living room of each unit has a picture window and door which take up a large section of one wall overlooking the grounds.

There are 23 rooms used by all of the children for their daily activities and which we call "community areas." All of these, except the canteen, are situated along two major corridors (Figure 1, D & I). These include a game room, a kindergarten, a music room, four occupational therapy rooms, the pool, gym, library and auditorium. The canteen is situated along the back corridor directly opposite two of the houses.

Additional indoor areas of the hospital include the school, administrative offices and an infirmary. The school area (Figure 1,J) is separate from the living and recreational areas and has an entrance from outside the building as well as one from the main corridor. The offices for all administrative functions and staff members (psychiatrists, psychologists, social workers, etc) are in a wing of the building which is separate from all other facilities (Figure 1,K). A fully equipped hospital unit is on the second floor of the building. There are three outdoor play areas (two with playground equipment) and an outdoor basketball court and baseball field. Outside the hospital are barbeque grills, benches and water fountains.

Procedure

In order to ascertain the actual use of space, three mapping studies were conducted. The basic approach used in quantifying and describing behavior patterns and use of space was the behavioral mapping technique, an observational method developed in previous studies. The mapping technique results in a set of statement or tables providing a profile of all activities observed, the participants, the time of the activity and the specific locations. We had previously developed standard procedures for obtaining behavioral maps of adult psychiatric wards. Prior to the present mapping studies, several months were devoted to adapting the mapping techniques for use with children, including the design of the observation instrument, the development of categories of children's behavior, the training of observers and determination of the reliability of the observation procedure.

The hospital opened as a limited day-care facility three months prior to the admission of full care children, and during this period observer training and reliability studies were undertaken. The initial mapping (Study 1) began the first day the hospital opened as a residential facility and continued for two weeks. The second study was conducted for a one-week period two months later, and the third mapping was done about four months later. In the periods between studies, weekly observations were made in order to keep abreast of all changes and developments.

The children's hospital was divided for observation purposes into two areas: the occupied house unit containing 24 rooms constitutes the living areas; the 23 rooms used by all children for daily activities (game room, arts and crafts, gym, etc.) constitute the community area. To obtain data for use in the maps, a time sampling method was utilized. An observer was assigned to each of the areas (living and community). Every fifteen minutes they would make a predetermined tour of the rooms, recording all ongoing activities, the number, residence status and sex of the patients, the number of staff present and whether the room was locked or unlocked. Each observed behavior was coded into one of 69 activities. For the purpose of data analysis,

TABLE 1
Description of Categories of Behavior

Category	Description of Behaviors Included
1. Aggression	Aggression toward objects, people, self and undirected; arguing; disturbing an activity; restraining a child.
2. High Energy Physical Release	Chasing; climbing; jumping off things, roughhousing, running.
3. High Energy Organized	Dancing, marching, rhythmicizing; exercising; active games, sports.
4. High Energy Unorganized	Play; fantasy play; roller skating; bike riding.
5. Low Energy Organized	Arts and crafts; sitting games; teaching; playing with or caring for animals.
6. Isolated Active	Looking out window at an activity; personal hygiene; reading; wandering; watching an activity; writing.
7. Isolated Passive	Crying alone; hiding; lying awake; sitting alone; sleeping; standing alone; looking out window.
8. Domestic	Eating and drinking; housekeeping; food preparation.
9. Media	Phonograph, radio, television.
10. Music	Play instrument; singing.
11. Orientation	Looking for a person; looking for a place.
12. Meeting	Group meetings; patient-staff conference.
13. Exploration	Explore objects; explore places.
14. Cuddling or Holding a Child	Self-explanatory.
15. Idiosyncratic Behavior	Pathological behavior which is specific to the person. Including head-banging, hallucinations, etc.
16. Talking	Self-explanatory.
17. Telephoning	Self-explanatory.
18. Traffic	Walking through, to or from an area with no other concomitant behavior.
19. Miscellaneous	Arriving; leaving; hospital routine; preparing for activity; transporting objects; waiting.

the coded activities were combined into 19 analytic categories cited in Table 1 (page 5-2-4). Observation periods extended from 10:00 AM to 9:00 PM. Study 1 observations took place for two weeks making a total of 296 separate observations for each room or area. Studies 2 and 3 covered one week each with a total in each study of 148 separate observations of each room or area.

Reliability

Before each of the two reliability studies, the observers were familiarized with the hospital and patients and were thoroughly trained in the use of the measuring instrument. Following training, pairs of observers would simultaneously collect a complete set of observational data. Two types of reliability scores were obtained, overall interobserver agreement and interobserver reliability for each variable. The overall interobserver reliability in Study 1 ranged from 81% to 96%. In Study 3 the range was 84% to 100%. The reliability of the observations in the two areas of the hospital (living and community) were essentially similar. Reliabilities for specific variables (locked status, number of patients) were sufficiently high to justify the use of the instrument (they averaged 87% in the first study and 91% in Study 3). The analysis of actual mapping data by 69 activities broken down by specific observer indicated that the various categories were used with equal frequency by all observers. Thus, there was no evidence of bias due to a specific observer. Interobserver reliability of coding activities was 78% in the first study and 85% in the second.

General Functioning of the Hospital

In order to evaluate the results of our studies, one must have a total picture of the functioning of the hospital. The children's hospital was ready for occupancy in December, 1968. Due to inadequate funds for staffing, the hospital remained unoccupied until December 29, 1969, when it opened as a day-care facility with 12 children. It operated on a day-care basis for two months, officially opening as a residential facility on March 10, 1970.

The original plan called for the admission of approximately 24 patients each month (16 adolescents and 8 children), and assumed that if adequate staff could be hired, at the end of the first six months of operation, with a 50% discharge rate, the hospital would have 72 patients. Even at the time of its official opening, funds for personnel were far below what was required. As a result, only a small number of children was admitted. The hospital opened with a census of four full-care and 12 day-care patients. By the second study, the census had increased to 11 full-care and 15 day-care patients. By Study 3, six months after the hospital opened, the census had only increased to 13 full-care and 15 day-care patients. In May, 1971, 14 months after the official opening, the census was 22 full-care and 30 day-care patients. In June 1971, severe budget cuts forced the closing of several state psychiatric facilities for children. The children's hospital was forced to admit more children, despite a concurrent freeze on hiring more staff. Between June and August 1971, 11 new children were admitted, 10 full-care and one day-care, bringing the census up to 32 full-care and 31 day-care patients. Since opening, only two children were discharged. Even with recent admissions, the hospital still is operating far below the capacity of 192 patients.

Due to the limitations in intake, there were vast, unused areas in the hospital, influencing patterns of use. Throughout the three studies, covering six months of occupancy, only one house was utilized. Even in this house, several bedrooms were not used, and were incompletely furnished. In fact, in all areas of the hospital furnishings were minimal due to inadequate staffing. A number of community areas, such as the canteen, pool, the library during Study 1, etc., were unused.

Changes in the philosophy and program of treatment must also be considered. During Study 1, the children were given a wide degree of freedom. All rooms were unlocked and available for use at will, and children had fairly unlimited choice of activity. By Study 2, hours were set for the use of all facilities, and rooms were locked, but they could be opened on request. By Study 3, all rooms were locked and only those children scheduled for an activity could use a given facility at a given time.

The effects of events in the general functioning of the hospital on space utilization patterns during its early months became clear in the analysis of the mapping data.

Mapping

The observational data were first analyzed to ascertain the frequency with which specific activities were observed during each of the studies undertaken. We call this measure "Frequency of Activity." These frequencies do not take into account the number of persons involved in these activities, but rather focus on the number of times an activity was observed to be occurring regardless of the number of persons involved. Frequencies of activity were obtained for patients and staff combined and for patients only. Such a measure provides a profile of the distribution of different types of activities. By examining the distribution for different areas of the hospital we can obtain a picture of how different areas were used and the stability or change in these patterns over time.

TABLE 2
Most Frequent Activity Categories
Studies 1, 2, and 3
Entire Hospital - Children and Staff Combined

	Study 1			Study 2			Study 3		
	(f)	%*	Rank	(f)	%*	Rank	(f)	%*	Rank
Talking	(714)	20.01	1	(307)	14.33	2	(315)	12.18	3
Traffic	(501)	14.04	2	(309)	14.42	1	(486)	18.78	1
Isolated Active	(411)	11.52	3	(223)	10.41	3	(363)	14.03	2
Hi Energy Org	(286)	8.01	4	(153)	7.14	7	(111)	4.29	7
Domestic	(227)	6.36	5	(156)	7.28	5	(72)	2.78	8
Hi Energy Unorg	(212)	5.94	6	(123)	5.74	8	(131)	5.06	6
Isolated Passive	(205)	5.74	7	(204)	9.52	4	(276)	10.67	4
Lo Energy Org	(179)	5.01	8	(155)	7.23	6	(185)	7.15	5
Total # Activities observed in entire hospital	(3567)	100%		(2142)	100%		(2587)	100%	

*Based on all activities observed in entire hospital for this study.

We compared the frequency of each activity in each area of the hospital to the total number of activities occurring in all areas of the hospital. These data allow us to see where, at any given moment of time, activities are likely to be distributed over all hospital areas. Then, we compared the frequency of each activity in each area to the total number of activities within that area only. This second measure enabled us to see how, at any given moment of time, activities are distributed within each specific area.

The first data we shall examine are the distributions of activities engaged in by staff and patients in the entire hospital over all days of each study. Table 2 presents the frequency of occurence and the ranking of the most frequent activity categories for the entire hospital for Studies 1, 2 and 3. Quite definite changes occurred between Studies 1, 2 and 3, reflecting the changing milieu of the hospital (Table 2). During Study 1, talking, the most unstructured social activity, was most frequent, accounting for 20% of all behavior observed in the hospital. By Study 3, talking account for only 12% of all behavior, moving to third rank, with traffic (movement to, from or through an area with no talking involved) replacing it as the most frequently observed activity. Isolated passive behavior (sleeping, sitting alone, etc.), on the other hand, rose 3 ranks from Study 1 to Study 3, from 7th to 4th most frequently observed activity, almost doubling in occurence. Thus, by Study 3, talking and isolated passive behavior account for almost equal amounts of activity, although when the hospital first opened, talking occurred almost four times as frequently as withdrawal behavior. Other activities show similar, although less dramatic changes. High enery organized behaviors dropped from 4th to 7th rank over time while low energy organized behavior rose 3 ranks.

If we examine the patterns of behavior for the children only, an almost identical picture emerges (Table 3). During Study 1, talking was the most frequent activity, accounting for 17.25% of all behavior. By Study 3, talking accounted for only 11.44% of all behavior, moving to 4th

TABLE 3
Most Frequent Activity Categories
Studies 1, 2, and 3
Entire Hospital - Children Only

	Study 1			Study 2			Study 3		
	(f)	%*	Rank	(f)	%*	Rank	(f)	%*	Rank
Talking	(301)	17.25	1	(154)	12.95	2	(156)	11.44	4
Hi Energy Org	(204)	11.69	2	(117)	9.84	5	(84)	6.16	7
Hi Energy Unorg	(187)	10.72	3	(96)	8.07	7	(104)	7.63	6
Lo Energy Org	(176)	10.08	4	(136)	11.44	3	(158)	11.59	3
Traffic	(172)	9.86	5	(118)	9.92	4	(176)	12.91	2
Isolated Active	(163)	9.34	6	(105)	8.83	6	(155)	11.37	5
Isolated Passive	(120)	6.88	7	(165)	14.04	1	(224)	16.43	1
Total # Activities observed in entire hospital	(1745)	100%		(1189)	100%		(1363)	100%	

*Based on all activities observed in entire hospital for this study.

TABLE 4
Most Frequent Activity Categories
Studies 1, 2, and 3
House and Community Areas - Children and Staff Combined

	Study 1				Study 2				Study 3			
	House		Comm.		House		Comm.		House		Comm.	
	(f)	%*	(f)	%*	(f)	%*	(f)	%*	(f)	%*	(f)	%*
Talking	(249)	6.98	(464)	13.00	(76)	3.54	(225)	10.50	(84)	3.25	(230)	8.89
Traffic	(72)	2.01	(427)	11.97	(48)	2.24	(259)	12.09	(45)	1.74	(439)	16.97
Hi En Org	(5)	.14	(273)	7.65	(27)	1.26	(126)	5.88	(6)	.23	(100)	3.86
Hi En Unorg	(29)	.81	(182)	5.10	(13)	.60	(99)	4.62	(16)	.61	(106)	4.10
Lo En Org	(29)	.81	(150)	4.20	(18)	.84	(137)	6.39	(6)	.23	(179)	6.92
Isol Active	(115)	3.22	(294)	8.24	(68)	3.17	(150)	7.00	(66)	2.55	(292)	11.29
Isol Passive	(95)	2.66	(109)	3.05	(130)	6.06	(72)	3.36	(207)	8.00	(67)	2.59
Total % Activity in Areas		28.49%		70.93%		27.95%		70.48%		25.52%		74.48%
Total # Activities Observed in Area		1019		2533		581		1514		648		1939

*Based on total number activities observed in entire hospital

place. For the children, isolated passive behavior which ranked 7th at 6.88% in Study 1 rose dramatically to become the most frequent activity in Study 2 (14.04%), remaining first in Study 3 at 16.43%. Thus, for the children, isolated passive behavior had become more predominant than talking. For the children also, the frequency of traffic rose considerably over time, high energy organized behavior dropped considerably, while low energy behaviors increased somewhat.

The changes in the entire hospital over the course of our three studies show a pattern evolving in which activities became less social and more passive or withdrawing and less likely to involve high energy. This pattern was similar for both the children and staff. It is especially interesting that the major pattern changes seem to have occurred by Study 2, only two months after the hospital opened and either were strengthened or remained the same by Study 3, six months after the hospital began functioning.

By examining the frequency of activities broken down by specific locations in the hospital, we can see how patterns of use evolved for each area. In all three studies, approximately 25 - 29% of the activity in the hospital occurred in the "house" or living areas while 70-75% occurred in the community areas. Thus, any changes in the pattern of activity within each area over time were not a function of overall changes in the distribution of the amount of activity within the area, but can be viewed as changes in the pattern of use of each specific area.

Tables 4 and 5 present the activities which characterized each area over all three studies despite changes which occurred within each area (these will be discussed below). Talking was consistently observed more frequently in the community areas as was traffic, high energy behaviors, low energy behaviors and isolated active behaviors. The only frequently occurring behavior which did not maintain a stable relationship between community and house areas over

TABLE 5
Most Frequent Activity Categories
Studies 1, 2, and 3
House and Community Areas - Children Only

	Study 1				Study 2				Study 3			
	House		Comm.		House		Comm.		House		Comm.	
	(f)	%*	(f)	%*	(f)	%*	(f)	%*	(f)	%*	(f)	%*
Talking	(119)	6.82	(182)	10.43	(48)	4.04	(106)	8.92	(48)	3.52	(108)	7.92
Traffic	(36)	2.06	(136)	7.79	(21)	1.77	(97)	8.16	(26)	1.91	(150)	11.00
Hi En Org	(5)	.29	(199)	11.40	(13)	1.09	(104)	8.75	(4)	.29	(79)	5.80
Hi En Unorg	(29)	1.66	(158)	9.05	(13)	1.09	(83)	6.98	(17)	1.25	(87)	6.38
Lo En Org	(25)	1.43	(151)	8.65	(17)	1.43	(119)	9.59	(6)	.45	(152)	11.15
Isol Active	(52)	2.98	(111)	6.36	(47)	3.95	(58)	4.88	(34)	2.49	(121)	8.88
Isol Passive	(65)	3.72	(54)	3.09	(119)	10.01	(46)	3.87	(179)	13.13	(45)	3.30
Total % Activity in Area		30.32%		69.57%		33.22%		66.78%		30.81%		69.18%
Total # Activities observed in Area		529		1214		395		794		420		943

*Based on total number activities observed in entire hospital

TABLE 6
Most Frequent Activity Categories in the House
Studies 1, 2, and 3
Children and Staff Combined

	Study 1			Study 2			Study 3		
	(f)	%*	Rank	(f)	%*	Rank	(f)	%*	Rank
Talking	(249)	24.43	1	(76)	13.08	2	(84)	12.96	2
Domestic	(134)	13.15	2	(57)	9.81	4	(31)	4.78	6
Isolated Active	(115)	11.28	3	(66)	11.35	3	(66)	10.18	3
Isolated Passive	(95)	9.32	4	(130)	22.37	1	(207)	31.94	1
Traffic	(72)	7.06	5	(48)	8.26	5	(45)	6.94	4
Media	(57)	5.59	6	(33)	5.67	6	(41)	6.33	5
Meetings	(30)	2.94	7	(21)	3.61	7	(10)	1.54	8
Lo Energy Org	(29)	2.84	8	(18)	3.09	8	(6)		
Hi Energy Unorg							(16)	2.47	7
Total # Activities observed in House	(1019)	100%		(581)	100%		(648)	100%	

*Based only on activities occuring within the house

all three studies was isolated passive behavior. Occurring with equal frequency in both areas of the hospital in Study 1, isolated passive behavior had become two times more frequent in the house area during Study 2 and almost four times as frequent in the house area by Study 3. This was true for both patients and staff combined and for patients alone. To pinpoint changes in the pattern of activities within an area, we computed the frequencies of each specific activity in an area over the total number of activities observed in that area only, rather than in relation to activity in the entire hospital. As Tables 6 and 7 indicate, there were substantial changes over time in the use of the house areas. In Study 1, talking accounted for 24.43% of activity in the house for both patients and staff and for 22.49% for patients only. Isolated passive behavior accounted for only one-tenth of the behavior observed in the house. Two months later an almost total reversal occurred -- isolated passive behavior now accounted for 22.37% of patient and staff behavior and for 30.12% of patient behavior. By Study 3, talking was at or slightly below the Study 1 level but isolated passive behavior continued to increase so that it accounted for 31.94% of the total activities observed for children and staff and for 42.62% of the children's behavior -- nearly one-half of all patient behavior occurring in the house. Clearly, by Study 2 the house had become crystallized as an area for withdrawal -- for both patients and staff alike.

The use of the community areas also changed over time. An investigation of Tables 8 and 9 (see page 5-2-9), indicate high energy behaviors decreased over time as did talking, while low energy behaviors, isolated active behaviors and traffic increased. Thus, even in the community areas the changing milieu of the hospital was apparent. Social behavior decreased, higher energy behaviors decreased and these were replaced by more isolated and low energy behaviors.

Discussion

The mapping data clearly indicate that space utilization patterns evolve from the earliest days of occupancy, creating an atmosphere for the hospital, but also reflecting the ongoing events in the building's life history. What

TABLE 7
Most Frequent Activity Categories in the House
Studies 1, 2, and 3
Children Only

	Study 1			Study 2			Study 3		
	(f)	%*	Rank	(f)	%*	Rank	(f)	%*	Rank
Talk	(119)	22.49	1	(48)	12.15	2	(48)	11.42	2
Isolated Passive	(65)	12.28	2	(119)	30.12	1	(179)	42.62	1
Domestic	(55)	10.39	3	(25)	6.32	5	(14)	3.33	7
Isolated Active	(52)	9.82	4	(47)	11.89	3	(34)	8.09	4
Media	(40)	7.56	5	(30)	7.59	4	(41)	9.76	3
Traffic	(36)	6.80	6	(21)	5.32	6	(26)	6.19	5
Hi Energy Unorg	(29)	5.48	7	(13)	3.29	8	(17)	4.05	6
Total # Activities observed in House	(529)	100%		(395)	100%		(420)	100%	

*Based only on activities occuring within the house.

TABLE 8
Most Frequent Activity Categories in the Community Areas
Studies 1, 2, and 3
Children and Staff Combined

	Study 1			Study 2			Study 3		
	(f)	%*	Rank	(f)	%*	Rank	(f)	%*	Rank
Talk	(464)	18.31	1	(225)	14.86	2	(230)	11.86	3
Traffic	(427)	16.85	2	(259)	17.10	1	(440)	22.69	1
Isolated Active	(294)	11.60	3	(150)	9.90	3	(293)	15.11	2
Hi Energy Org	(273)	10.77	4	(126)	8.32	5	(100)	5.16	6
Hi Enery Unorg	(182)	7.18	5	(99)	6.53	6	(106)	5.47	5
Lo Enery Org	(150)	5.92	6	(137)	9.04	4	(179)	9.23	4
Total # Activities observed in Community	(2533)	100%		(1514)	100%		(1939)	100%	

*Based only on activities occuring in community areas.

TABLE 9
Most Frequent Activity Categories in the Community Areas
Studies 1, 2, and 3
Children Only

	Study 1			Study 2			Study 3		
	(f)	%*	Rank	(f)	%*	Rank	(f)	%*	Rank
Hi Energy Org	(199)	16.39	1	(104)	13.10	3	(79)	8.38	6
Talk	(182)	14.99	2	(106)	13.35	2	(168)	11.45	4
Hi Energy Unorg	(158)	13.01	3	(83)	10.45	5	(87)	9.22	5
Lo Energy Org	(151)	12.44	4	(119)	14.99	1	(152)	16.11	1
Traffic	(136)	11.20	5	(97)	12.21	4	(150)	15.91	2
Isolated Active	(111)	9.14	6	(58)	7.30	6	(121)	12.83	3
Total # Activities observed in Community	(1214)	100%		(794)	100%		(943)	100%	

*Based only on activities occuring in community areas.

form does this take? The stated functions of specific areas, that is, the gym as a place for sports, the O.T. room as a place for arts and crafts, resulted in patterns of use appropriate to these functions. As our data indicate, there were activities that consistently occurred in one area of the hospital as opposed to another. Over time, however, these patterns of behavior came to reflect more than the name of a room -- they came to be a product of the physical design and function of the rooms, but in addition the administrative policies set up for their use. Yet, the administrative policies did not occur in a vacuum, and our study indicates that they changed in large measure in response to problems emanating from the design of the building. These two factors, then, the design of the facility and the administrative and therapeutic philosophy interact with each other.

In the children's hospital, designed for 192 children yet occupied by only 28 children six months after occupancy, vast unused areas presented unexpected problems. These included issues of control, morale and flexibility. The relatively unstructured therapeutic program at the beginning of occupancy resulted in a considerable degree of freedom of choice in space usage. While the community areas had a somewhat defined character resulting from room function, even here we observed behaviors that did not continue at later stage, i.e. roller skating in the halls. And even defined rooms had activities occurring within them that were not directly related to function -- talking, for instance. The house at the beginning had no distinguishing pattern. In comparison with community areas, less of everything went on there and more of no one specific activity. The house was basically characterless. The therapeutic program involved on-the-spot therapy sessions, so that a child acting-out was confronted wherever he happened to be, i.e. in the corridor, in the gym, etc.

By the second study, several changes had occurred both in administrative policies and in space utilization patterns. Staff had difficulty in controlling and supervising the small number of children in the large space. Children could easily leave the hospital by any one of a number of exits and the limited staff could not police all areas. Children had climbed up to the roof and had run away. They had intruded on the administrative areas. If a child ran down the corridor, there were 15 doors he could disappear into -- to hide, to disrupt activities, etc. The resultant decision was to change administrative policy. Hours were set for the use of facilities; rooms were locked. Paper was used to cover glass panels in doors of activity rooms to prevent distraction from within and disruption from without. There were still some options for the child in that he could request that a room be unlocked, but he could not be as spontaneous in his selection of activities as before.

Space utilization patterns reflected the general atmosphere of the hospital. There was a general structuring imposed on the facility -- less freedom in the use of spaces, less variety in what was going on, and less high energy activities. The limits to the freedom of choice apparently communicated a message to the children and staff alike that specific activities should take place in specific places. In fact, some of this might have reflected the general settling-down of a new institution, but we feel that there was a real change in basic philosophy as the staff met the demands of a partially-occupied building. The resulting space utilization patterns were revealed in use of the house as a place for withdrawal, defining the general character of the house. There was a concurrent toning down of other behaviors in the community areas. What was available for a child? A decision had to be made to either participate in structured (now basically low energy) activities in the community areas or retreat to the house. Sacrificed in these choices were the casual social encounters, and this can be seen in the decrease in talking. This administrative structuring, in large measure a response to problems in an underused physical facility was strenghtened by Study 3, in spite of a small increase in the number of children. The house was institutionalized as an area of withdrawal, with isolated passive behaviors representing almost half of all activity there. Our recent observations indicate that this pattern remains, even with a population of over 60 children. In fact, the office in the house has been made into a seclusion room for use with children with acting-out problems.

The studies, thus far, indicate that it is possible to distinguish and categorize the activities and uses of space in a children's psychiatric hospital, and that activity can be related to the therapeutic philosophy of the hospital. These empirical data provide a source of information for hospital administrators as to the efficacy of their therapeutic philosophy as well as possible areas for change. In terms of the design of facilities, the data could provide the objective basis for design decisions, and our future studies may enable us to make specific recommendations. It is also clear that the partial use of a total facility makes it difficult to utilize the design of a building as part of the therapeutic philosophy and, in fact, can undermine it. The recurring theme of control, evident in our data, appears to be the result of the partial use of the building as well as insufficient staffing. The interaction of the program and design factors can result in unanticipated and sometimes undesirable uses of space. The low census and the large unused areas which led to control problems and the subsequent tighter structuring of the use of facilities was accompanied by the crystallization of the house as an area of isolated withdrawal -- a pattern which remain despite increased census and the use of more areas. Thus, these data underline the importance of considering the physical setting and the therapeutic philosophy as interactive factors.

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THE PRE-SCHOOL CHILD NEAR ENVIRONMENT: VARIABLE MANIPULATION AND EVALUATION

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Abstract
A study of the relationship between the behavior of pre-school children and the physical near environment has been initiated at Cornell. Illumination and sound levels, color, equipment, and spatial configurations in a nursery school room will be varied. Systematic observational records will be kept of the level of play, the incidence of aggression, and movement in and out of, as well as within, the test area.

PLAY: THEORY AND RESEARCH (1)

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Science is concerned with knowing; practice with doing. The communication gap between practitioner and theoretician in the management of play seems to be wide. This is because many of the people concerned with either the management of play or theorizing about it are confused about their roles. It is the responsibility of the scientist to produce principles, laws and theories that can be used generally to relate cause and effect. The scientist is concerned with removing the specificities from a problem so that his findings may achieve general application.

On the other hand practitioners are responsible for adding the specificities to the mix in order to maximize a goal. Practitioners are concerned with value judgments and peculiarities. The output of the researcher-theoreticians is their input. Practitioners need this input so that they may evaluate the products of their practice. If practitioners cannot conceptualize and communicate their procedures they cannot evaluate whether they reached their goal and then cannot communicate the process to others. Without communicable principles of design and evaluation we will stay stuck in a morass of opinions and feelings.

So the role of the scientist and practitioner are complementary, one dealing with generalizations and the other specificities. Both are intimately concerned with the search for principles of play behavior that will enable an upward spiral in the quality of play management to begin. So endeth my sermon on our roles which I hope explains the purpose of this paper which is to try to communicate why animals and people play, and some things we have found that you might be able to use.

Now to some theory that will I hope simplify for you your bewildering task of designing and managing play environments for people. Older theories of behavior still work well when there is some need to be satisfied. Each need is signalled by some sensor that sends signals of increasing urgency as the need increases. When the animal responds and satisfies the need it is rewarded by the elimination of the signals for a time. These need-reduction theories of hunger, thirst, etc., are built on an assumption that the animals' goal is quiescence. Need-reduction is work and it is assumed that when all the work is done the animal sits quietly till the next need rears its head. It is clear that many animals do not seek quiescence when satiated. They continue to behave. The behavior is not work, therefore it is----let's call it "play".

To return to the quiescence notion; some animals do seem to follow the need-reduction model, but others do not. The differences between these groups suggests some important concepts concerning play. I am going to borrow some material that has been published elsewhere that says what I want to say here (5).

> These two classes of animals can best be labelled the "generalists" and the "specialists" (2). Specialists are animals that are very well adapted to a particular environment doing the few things necessary for their survival extremely well. When not performing their limited number of responses they relax, uniquely adapted to the *status quo*. They are exemplified by snakes, frogs, etc. Generalists are quite different. They are not adapted exclusively to any particular niche but are capable of adapting to a variety of environments. They are opportunists living by their wits. They maintain a large variety of responses and are forever testing and probing the environment, playing with it, even when not hungry. By this process they keep abreast of change and the more up to date ones tend to survive. The generalists' curiosity, their tendency to explore, manipulate and control the environment is characteristic of rats, bears and primates, etc. Man is the prime example.
>
> Generalists have an abhorrence of sameness; in our terms they become bored. They need constant opportunities to deal with the environment. If they are deprived of opportunities to do this then they create them. Men cannot tolerate the absence of stimulation, and may be considered to play when they maintain their interactions with the environment after insuring their immediate survival. Play can be seen, then, as

a type of arousal-seeking behavior. It prevents boredom and generates a base of information about the environment from which to operate.

Animals are changed by their experience and become more complex as they get to know things. Things that become completely known cease to be interesting. Only things that are somewhat new, or to some extent uncertain, are interesting. Thus, with increasing experience an organism's interactions with its natural environment gradually increase in complexity. Presumably there are limits to this, either set by the complexity of the environment or by the animal's ability to deal with complexity. A dumb generalist in a rich environment is limited by its own capacity to get to know the environment, whereas a sharp generalist in a limited environment soon knows it well and begins to suffer from stimulus deprivation.

Play seems to be arousal-seeking behavior that leads to an increasing complexity of the players and their play. Further, the evidence suggests that appropriate opportunities to deal with unknown elements in the environment are crucial to the development of our children. If you accept the above, then shed a tear with me for the opportunities we have lost to enrich our children's lives.

Luckily for our planners and manufacturers children will play with a cardboard box, a scrap of wood, and playgrounds. Their propensity to play ensures this. Yet a hard-nosed look at usage patterns of our conventional playgrounds show that they do not sustain the attention of their clients. For example a recent study in a variety of different locations in Philadelphia (15) showed that children visited only once per day and then for only fifteen minutes. Children in the most depressed environment with presumably least opportunities for play and perhaps greatest need showed the same pattern. Further, the study showed that on the average the play apparatus was vacant at least 88 percent of the peak time. The conclusion that playground activity features low on the behavioral popularity poll and are used only when nothing else is happening was confirmed by Dee and Liebman (3) in their study of attendance at urban playgrounds. It is possible to compare the behavior in many traditional playgrounds to those aimless stereotyped mechanical responses of our furry relatives pacing their cages in chronic boredom.

The golden rules for design need to be based on a theory and frankly, tne one outlined in brief above is the theory of play that recommends itself by seeming to explain much of what is happening during play. To use it then leads to the following:

1. Children play for the stimulation they receive not just to burn up energy.

2. Children need to indulge in activities that become increasingly complex with time.

3. As a by-product children learn about their physical surroundings, and about their own roles in a social group.

The essential characteristic for a playground is that it should elicit new responses from the child as he plays, and that these responses increase in complexity as play proceeds.

For new responses to be elicited, the objects in the play environment must be manipulable by the child. Currently much apparatus merely allows the child to manipulate himself by swinging, or whirling, etc. This is important, but goes only half way. The items that sustain attention and generate the greatest number of responses are those that are manipulable. The items manipulated should by their interactions demonstrate relationships that exist in the physical world, and some should lead to social organization among the players. Finally, in Utopia, the playground would change regularly, say once a month, so that the children it serves are regularly challenged to explore and exploit a new environment.

Most of the concepts contained above are exhibited by adventure playgrounds, those delightful areas filled with bricks, lumber, dirt, scrap metal. Here the children can dig, build, change their environment and undertake cooperative projects that can last a whole summer. If we can add to those kinds of playgrounds the new devices as they are developed that seek for specific goals by leading the child to learn by his own actions, then we have achieved the pinnacle of our current state-of-the-art.

With the above in mind the following questions might be asked about items being considered for inclusion in a play area.

Which manipulates the child in the greater variety of ways?

Which allows the child to manipulate it in the greater variety?

Which pre-empts the behavior of the child least?

Which allows for cooperation between children?

Which seems to be capable of teaching most, or which seems likely to teach what you want the children to learn?

Moving to a higher order of question:

Which combination of items maximizes the variability of behavior exhibited?

Which set or combination will allow rearrangement of the setting to extend the possibilities for play either by the introduction of change, or by increasing its complexity through a season?

These central ideas stated in general terms, can be taken by a planner and applied to the particular set of conditions that exist for his clients. A set of questions stemming from a definition of play as arousal-seeking behavior, is derived whereby play-things or -grounds, can be rationally considered from the viewpoint of the child. No particular items are condemned but much of the apparatus produced by the industry does not stand up well to the questions established as guides to planning. Finally, at this time there is no single answer to any planning decision. Within limits there are many solutions to a local need and a healthy diversity of solutions coupled with evaluation of each product is the only way we shall evolve a technology sophisticated enough to reflect the complexity of play behavior.

Based on the theoretical system described above have been a series of studies that have investigated the novelty and complexity of the play environment. These studies showed that with increased exposure the reduction in novelty that ensues alters behavior. Wuellner _et_ _al_. (17) first showed that the activity in a group of boys and girls playing on the same material in our play research lab usually diminished steadily over time. Then both Jeanrenaud (10) and Lovelace (12) showed that the time taken to resolve the conflict between the desire to approach a novel play apparatus and play, and the desire to cautiously avoid interaction with a strange object diminished as the object became more familiar. Both of these findings are consistent with the concept that the information inherent in the setting is consumed by children as they interact with it.

Literally, in another direction, Karlsson (11) attempted to quantify the height preferences of children at play to study the theory and to produce information relevant to the design of play environments. She hypothesized that Wuellner's findings were caused by the children changing their behavior from interaction in a horizontal plane to vertical activity or climbing over time. To test this the height preference of nursery school children were studied over a series of 5 free-play sessions using the height to which the children climbed as the measures. The apparatus in the playroom utilized the full 9' height of the room and was of 3 basic types: Flat (boxes); Barred (trestles) and Unstable (rope-net). The children's height preference was measured in two ways; height to the point of support and the height to their eye level. Play on these apparatus presented differing task complexities which created different height preferences measured both ways. As expected the more complex the item the lower the children played. The expected trend towards an increased preferred height over time did not occur, supporting Wuellner's original assertions that the quantity of behavior diminishes as the setting becomes familiar. However, it may be merely that 5 sessions was not enough to show a trend as the children became more daring.

These kinds of studies have become possible because satisfactory methods have been developed for studying the behavior of children in a play environment. One useful method for collecting data concerning the position of playing children in time/space has been developed in our laboratory. The data is collected automatically, photographing the play space at intervals through a fish-eye lens mounted above the area. The resulting 35mm film strip is then projected onto a grid that accounts for the distortions introduced by the lens. The grid enables the positions of the various children in the horizontal dimension to be scored by hand (17). The coordinates recording position in space for each time sample are then punched on cards. The computer is then used to derive from the same basic raw data such measures as total distance covered, frequency of use of various items in the room, distances between children, time on apparatus, etc (9).

The camera system is reliable, objective, unobtrusive, simple, and is not costly to run (relative to the employment of several observers). Its only disadvantage is that it is time-consuming for one scorer (4).

The methods described above have led to much experimentation that has given equivocal results indicating that play behavior of children is extremely complex which is something you already know well. It also points out that it is difficult to proceed with the sophisticated experimentation that will precede the control of that behavior. The methods, however, lead to three types of derived dependent variables best categorized as activity measures, equipment use measures and measures of the social structure in the play situation. So this method holds promise for application in a variety of situations including the evaluation of playgrounds.

A different and coordinated set of studies, derived from the fact that the play of children is always shaped to some extent by the physical environment in which it occurs, have been carried out in our laboratory. Stimulus properties of play objects comprise a crucial portion of the child's environment. The effects of specific stimulus factors on play should hold great interest for the basic researcher concerned with fundamental questions relating to play and for the designer working to optimize children's play environment. Necessary research should divine as well as measure the effects of variation within and between stimulus features of play objects. Such investigations of stimulus properties of play objects has been pursued at our laboratory and two sets of findings have been replicated. The first is that children exhibit a preference for using a play item placed in the center of a play area. This "centricity" effect indicates position as a powerful stimulus parameter (16).

Further, a second group of studies involving standard school size play blocks showed no basic color preference among the nursery school children tested, but some indication of preference for blocks was determined by their being placed in the outer piles in a semi-circular array of 4 piles (8).

This approach was also applied to the common observation that children like to play in encapsulated spaces. The reasons for children's propensity to play in cardboard boxes, old refrigerators, under tables, was examined by Gramza (6). By manipulating the number of open sides in a series of hollow 2 foot cubes (the degree of enclosure) in an experiment the children's preferences for complete enclosure was clearly demonstrated and has been replicated on other sizes of capsules.

This study of encapsulation was extended to ask the question what were the attributes of a capsule with only one open side that was attracting usage. With size (32 inch cubes) and material (plexiglas) being held constant, visual aspects (stimuli) of the boxes were varied. When sides were made transparent, translucent and opaque, it became possible to answer whether the capsule was attractive because of darkness, visual separation, or because it merely provided a tactile (touchable) bounding of space. In this study both opaque and translucent boxes were preferred over the transparent boxes indicating that in addition to a preference for occupancy of a touchably finite space there was additional attractance created by visual separation.

Another series of studies conducted in the same setting described the relative attractance of complex versus simple apparatus. The theoretical basis for this work stemmed from research showing that stimulus complexity is an important parameter for preferences and from characterizations of play as stimulus or arousal-seeking behaviors.

This has considerable relevance for play environment design and suggested an empirical test using objects that were similar to the climbing playthings appearing regularly in playgrounds. The study progressively complexified one of two 8 feet tall climbing trestles. Repeated exposures were given to allow for separation of novelty from complexity in children's preferences. The outcomes, as usual were not straightforward. For example the effect of position appeared again to complicate the issue, and boys tended to maintain exclusive use of a favored trestle over girls.

However, initially the first stage of the two stage complexification created greater usage but after a while the simpler trestle was used more. The second stage of the complexification process resulted in lasting preferences for the complex trestle. To explain this the experimenter, Gramza _et al_. (7), suggests that the first stage of complexification was actually a simplification. In the first stage large sheets of plywood with foot holes were bolted to the sides of the trestles. While this was novel the children preferred it, but as the novelty wore off it was revealed that the series of bars to which the sheets were bolted were not available to sustain a variety of climbing and swinging behavior. The second stage complexification involved smaller sheets, platforms, ramps and ropes that added to the behavioral possibilities rather than subtracting. Accordingly, the second stage was sustainedly more attractive.

These effects exemplify the need for knowledge of apparatus stimulus parameters before a technology for manipulating play behavior can be developed.

The data and theoretical formulations exist, and we face a twofold challenge to continue our work and to interpret to you the findings in a way that makes them useful. Our best bet seems to be to build a theory and to support that theory with hard data on the effect of various design decisions of children's play behavior. Today was, hopefully, the first installment.

Notes

1. A rewritten and extended interpretive article based on a presentation made under the same title to the National Symposium on Park, Recreation and Environmental Design on February 16, 1971 in Chicago. The paper has been prepared from research conducted by M. J. Ellis, A. F. Gramza, R. E. Herron, K. A. Karlsson, R. J. Korb, P. A. Witt and L. H. Wuellner while they were on the staff of the Motor Performance and Play Research Laboratory. The research was supported in part by a research grant to that laboratory via the Adler Zone Center, by the Department of Mental Health of Illinois and by USPHS Research Grant MH-07346 from NIMH.

2. Morris (1 , 1) originated this differentiation with the use of the words neophilia and neophobia, literally, novelty liking and novelty avoiding animals. However, the words generalists and specialist express the idea more directly.

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6: METHODS FOR INVESTIGATING IMAGERY AND MEANING

MEASUREMENT OF CHILDREN'S PREFERENCES FOR THE PLAY ENVIRONMENT

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Abstract

A measurement technique employing photographs and comparative judgement scaling is evaluated for internal consistency and behavioral validity, with positive results. Using the validated technique, the hypothesis is tested that adult designers are insensitive to children's preferences, and the hypothesis is found to be true. The measurements thus obtained also contain useful information about the substance of what children prefer, and this is discussed briefly.

Acknowledgements

This paper is based on Bishop's doctoral research done at Northwestern University under the direction of Peterson. Financial support was provided by the Environmental Control Administration of the U.S. Public Health Service. The time-lapse photography was financed by a grant from the Sloan Foundation to the Design and Development Center of Northwestern. The cooperation of elementary schools in the Chicago metropolitan area also contributed to the success of the project. However, conclusions and errors are the responsibility of the authors and not of the granting or cooperating institutions.

Introduction

The preferences of children are rarely considered in the environmental design process, even when the product is intended specifically for them. One of the reasons for this is that it is difficult to gather meaningful information from children. They have short attention spans and their skills are not well developed. Another reason is that economic, political, and planning processes are not organized to allow direct participation of children in representing their own interests. If these interests are represented at all, it is through adult "advocates" who are understandably preoccupied with their own perceptions of the children's health, safety and morals. More often, however, the child is simply ignored as a user of the urban environment. Thus, children tend to be discriminated against in the environmental planning and design process because they lack capability and opportunity to express themselves effectively.

The situation is aptly described by Dattner in his discussion of children and the design of urban facilities that affect them. He defines a spectrum of users of urban facilities in terms of the extent to which the users are affected. He places children in the most and administrators in the least affected category.

> Although they (the children) are the most deeply affected groups of users, they are presently the least able to influence the design of their environment. Not only are children seldom consulted about these matters, but their needs are almost completely forgotten when the facilities are being designed. The important decisions are made by another group at the other end of our spectrum of users. (1)

It will contribute to the remedy of this problem if methods can be developed which reliably and accurately measure the preferences of children. Like any other environment, the playground should be planned and designed with many factors in mind. Accessibility (2), cost, maintenance, safety and separation from adults should all be considered. (3) (4) Also important are the constructive functions of the play experience in the child's physical, emotional and social development. More basically, however, it is the potential satisfaction of children as users of play facilities which should be of primary importance in the planning and design process. Their use of a place intended for play is by their own free choice. If a playground or a piece of equipment is not competitively attractive to them, children will not use it, and it must be regarded as a failure. Even if a relatively unexciting play environment is used because it is the best of alternatives, a fundamental responsibility remains to maximize the users perceived satisfaction, subject to the constraints imposed by health, safety, morals and economics.

The subject of this paper is the measurement of children's preferences in the context of playground design. The purpose is to describe briefly the procedures and results of a research project that has concerned itself with three basic objectives: 1) to evaluate a simple and inexpensive methodology for gathering information directly from children concerning their preferences, 2) to test the hypothesis that adult designers and administrators are insensitive to the preferences of children, and 3) to gather new information about what is attractive to children and to suggest some design guidelines.

Validation of Methodology

The first purpose of this paper is to summerize the results of a study aimed at testing the reliability and validity of a measurement technique. Briefly, this technique is to use photographs as stimuli in an interview that asks children directly for their preferences. The method of paired comparison is appealing for use with children because of its simplicity. This procedure is well developed in theory and yields interval scales. (5) (6) The respondent is required only to select the most desirable of two alternatives. However, as the number of alternatives increases, the number of pairs that must be examined grows combinatorially. Thus, fatigue becomes a serious problem.

The method of rank order is similar in theory and result to paired comparison but requires the respondent to make more complex decisions. In its simplest form, the method asks the respondent to pick the most desirable of several alternatives, rather than of only two. However, for a given number of alternatives, the number of operations is generally reduced. If the increased complexity of rank order does not detract significantly from reliability and validity of the measurements, it is to be preferred over paired comparison because of its ability to handle larger numbers of alternatives. Before such methods are used to measure the preferences of children, three major questions must be answered:

1) Can children make meaningful choices between and among photographs so as to yield reliable and internally consistent average preference scales?

2) Does the method of rank order produce results that are in agreement with the simpler method of paired comparison?

3) Can the scales thus derived be used to predict the actual average desirability of play equipment in real playground situations?

The first two questions have been studied in general in the psychometric literature, but to our knowledge, use of the methods with children has not been explored. The third question, behavioral validity of using photographs in conjuction with these scaling and measurement methods is a perennially raised but never answered question.

With the cooperation of officials of Lincolnwood School in Evanston, Illinois, the following operations were performed:

1. The six pieces of equipment in the Lincolnwood playground were photographed individually in color, and the photographs were each enlarged to 5" by 7" on individual cards.
2. Forty-five eight-year old children rated the desirability of each photograph using the methods of paired comparison and rank order in two independent tests. This was done twice. The first time was in October, 1970, and the second time was in January, 1971.
3. Using the law of comparative judgment, an interval scale of average desirability was constructed for the six photographs from each of the four data sets. These scales are shown in Figure 1 (next page).
4. Each of the four preference scales was tested statistically for internal consistency. This was done by using scale parameters, (mean and dispersion) to generate a synthetic data set which was then compared statistically with the original data.
5. The four scales were compared between methods and over time for ordinal and interval consistency.
6. During the summer of 1970 a time lapse movie camera was concealed in the school building overlooking the same playground, and the actual play behavior of children using the six facilities was recorded. A total sample of 2000 usable frames was obtained with time separation of from one to three minutes between adjacent frames.
7. Using carefully designed techniques, a sample of 550 frames was used to calculate the probability of use for each of the six pieces of equipment.
8. The four preference scales obtained from the photo interviews were used to predict

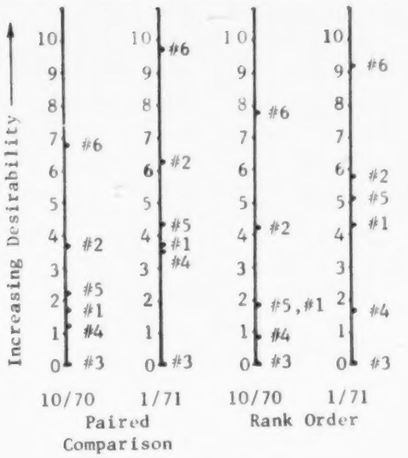

FIGURE 1

Children's Preference Scales

Derived From Interview Responses to Photographs By the Law of Comparative Judgement

(The scales have interval properties but not ratio properties. The origin is arbitrary.)

KEY:
#6 = Swings = First Choice
#2 = Slides = Second Choice
#5 = Hor. Ladder = Third Choice
#1 = Monkey Bars = Fourth Choice
#4 = Seesaws = Fifth Choice
#3 = Hilo Bars = Sixth Choice

synthetic probabilities of use for each of the six pieces of equipment.

9. Predicted probabilities were compared with observed probabilities to test the hypothesis that the two methods yield the same results. Strong correspondence between the predicted and observed probabilities would be evidence that the measurements derived from the photo interview are meaningful indicators of preference.

The details of each of these operations are explained elsewhere. (7) (8) (9)

Results of the Validation Study

The four scales calculated from the photo interview by the law of comparative judgment are shown graphically in Figure 1. Tests for internal consistency show that each scale is a valid and stable measurement of a preference process. Thus, it can be concluded that children are capable of responding meaningfully to the photographs, using the methods of paired comparison and rank order. Figures 2 and 3 show graphical and statistical comparison of the scales between methods and over time. The correlations are extremely high, which demonstrates that the two methods are reliable in the aggregate and yield stable and identical results. Thus, children are capable of using rank order methods as well as paired comparison methods. The scales are ordinally identical over time and across method. Statistical comparison of the interval properties of the scales shows that the observed differences can reasonably be attributed to chance. (10) This demonstrates that the scales have reliable interval meaning, also.

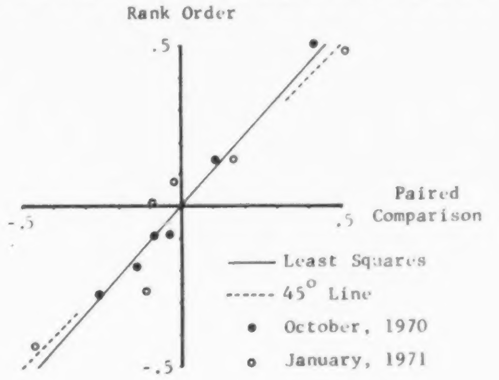

FIGURE 2
Consistency of Scales Between Methods

$R = 0.969,\ R^2 = 0.939$
$(PC) = -0.0075 + 0.906(RO)$

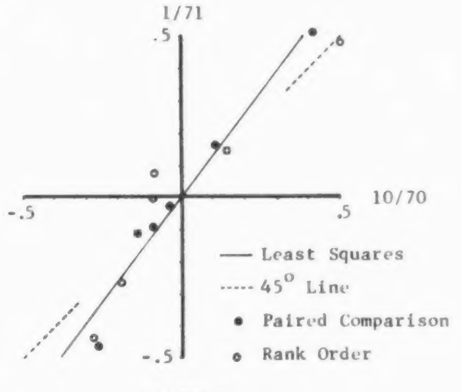

FIGURE 3
Consistency of Scales Over Time

$R = 0.952,\ R^2 = 0.905$
$(10/70) = 0.00072 + 0.770(1/71)$

Figure 4 shows the relationship between the observed probabilities and the probabilities predicted from the four preference scales. Here the correlation is much too high to have occurred by chance alone. The two independent data sets have fifty-seven percent of their variance in common. This allows us to conclude 1) that the interview preference scales are significantly related to actual behavior, but 2) that some differences exist between the photo preference process and the behavior observation process. The correlation is sufficiently strong, however, to justify cautious use of photo preference scales as indicators of "true" preference. Note that the extremes correspond perfectly. The disagreement is caused by the pieces of equipment in the middle preference range that are very close together on the interview preference scales.

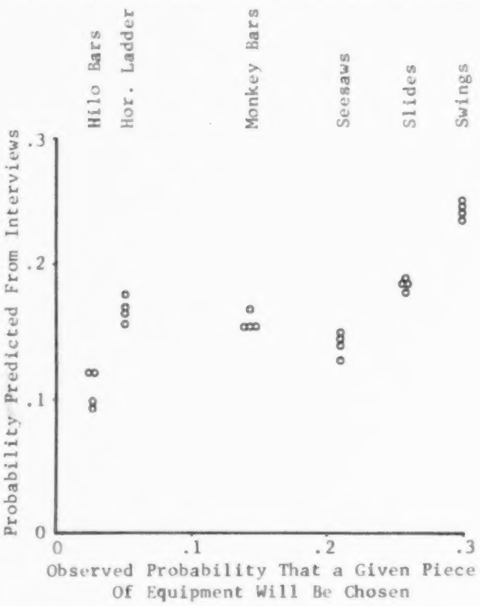

FIGURE 4

Agreement Between Interview Results And Behavioral Observation

R = 0.757, R^2 = 0.573

An important observation about the relationship in Figure 4 is that the behavioral observations discriminate more strongly among alternatives than do the interview preference scales. This suggests the possibility that the interview preference process is less sensitive to differences in the desirability of alternatives than actual behavior. This would be expected, because the child is not forced to accept the actual consequences of his decision when choosing among photographs.

Sensitivity of Designers to Children's Preferences

It was suggested in the introduction that the design process is not responsive to children's preferences. This was the justification for exploring measurement techniques. The second purpose of this paper is to summarize the results of a study that tests this hypothesis using the methods described above. This test was accomplished by 1) measuring children's preferences for sets of carefully selected photographs, 2) measuring what adult designers believe are children's preferences for the same photographs, and 3) comparing the results quantitatively and qualitatively.

In order to get a wide coverage, five sets of photographs were used. These were carefully designed to display, respectively,

1. Variations in the play environment
2. Variations of activity or play equipment
3. Slide design variation
4. Climbing apparatus design, and
5. Effects of user crowding.

Each of the first four was a set of fifteen photographs, while the last was a set of five. The larger sets were used with rank order measurement, and the last was used with paired comparison. The complete results are reported elsewhere. (11) (12) Detailed analysis of the results of the five comparisons is the subject of another paper currently being prepared. (13) Because of the need for brevity, only one of the studies, slide design variation, is discussed here, and the report is confined to a brief description of the study and a summary of the quantitative results.

Slide Design Variation: An Example

Space does not allow inclusion of the photos. The fifteen pictures were selected to cover a wide range of variation in the design of slides. They include examples of thematic, innovative, imaginative, functionally exciting and traditional or plain designs. There was no attempt to isolate specific attributes of design in an explanatory sense other than to identify types or categories and to include a wide range of alternatives that are fairly representative of available designs. These photographs were used to measure the preferences of two hundred eight-year old children, uniformly stratified by sex, ethnicity (black or white, only) and place of residence (Evanston vs. Chicago, only). Thus the sample consisted of twenty-five children in each of eight categories.

For purposes of comparison, fifty adults were interviewed using the same photographs. They were people in the business of designing and delivering playgrounds and play equipment. The sample consisted of twenty-five senior landscape architecture students from Purdue University and twenty-five professionals from the Chicago Park District. These people were asked to play the role of eight-year old children and select the photographs the way they believed children would. They were not asked to give their own preferences. Rather, they were asked to give what they believed to be children's preferences.

Figure 5 compares the preferences of male children with those of female children. The correlation of 0.96 is extremely high and shows that the two independently derived scales are essentially the same. Figure 6 is a similar comparison between blacks and whites. The correlation here is also 0.96, but the numerical identity is purely coincidental. The high correlation shows that the two ethnic groups have remarkably similar preferences for the slide design variations.

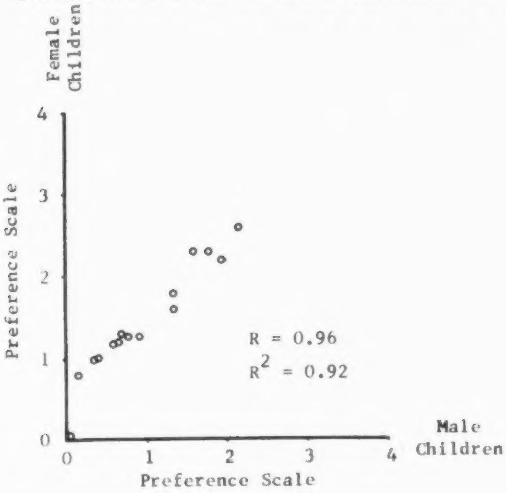

FIGURE 5

Comparison of Preference Scales Constructed For Male and Female Children

SLIDE DESIGN VARIATION

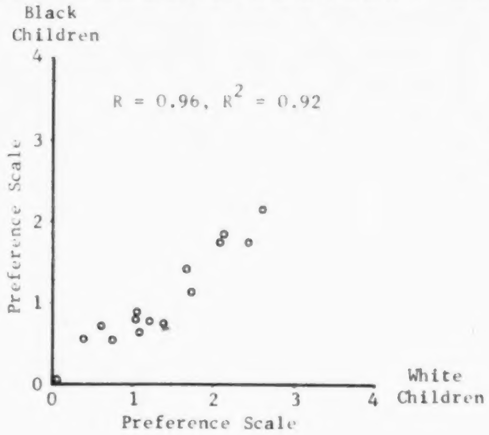

FIGURE 6

Comparison Between Preference Scales Constructed For Black Children and White Children

SLIDE DESIGN VARIATION

In Figure 7 the correlation between children's preferences and the beliefs of adult designers is only 0.56. This means that the two scales have only 31% of their variance in common whereas the communality in both the sex and the ethnicity comparisons was 92%. Using a normal test of reliability for the correlation coefficient shows that the probability of obtaining an adult/child correlation as large as 0.56 from an uncorrelated population with a sample size of 15 is only 0.03. This suggests that the two scales are positively correlated. However, a 95% confidence interval lies between 0.06 and 0.84. The adult/child correlation is thus statistically as well as numerically lower than the child/child correlations across sex and ethnicity. This supports the hypothesis that the designers are relatively insensitive to children's preferences, at least in the case of slide design variation. The hypothesis is also supported in the case of variations in the play environment, activity variation, and climbing design variation. (14) This leads us to conclude that the systematic measurement of children's preferences is an essential step in design if the facilities are to be attractive and satisfying to the children. The design challenge is to create alternatives that are both attractive and functional (i.e., safe, constructive, economical, etc.).

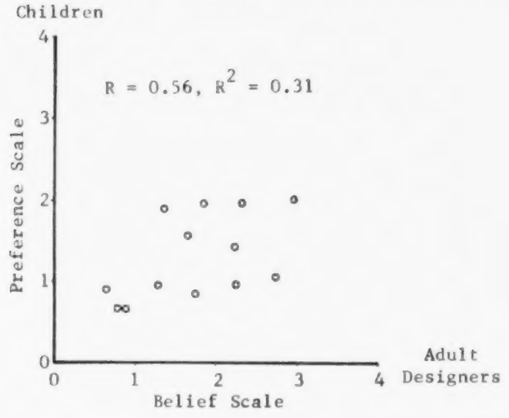

FIGURE 7

Comparison of Children's Preferences and Adult Designers' Beliefs About Children's Preferences

SLIDE DESIGN VARIATION

Conclusions about Children's Preferences

In the process of validating methodology and testing designer sensitivity, considerable information was gleaned about what children prefer. For example, in the pilot study it was established conclusively that of the six traditional designs studied, swings and slides are considerably more attractive to children than horizontal ladders, monkey bars, seesaws or horizontal bars. It was further established that horizontal bars are considerably less attractive than any of the other five facilities. These results were obtained consistently from four independent interviews and were verified thru unobstrusive behavioral observation. We now are in a position to ask 1) whether innovative, thematic or colorful design variations might affect attractiveness, 2) how children react to a wider variation of alternative facilities, 3) how variations in the play environment affect preferences, and 4) what are the effects of crowding? The comparative and substantive results of these studies are described only briefly here, in qualitative terms.

Comparative Findings

In general it was found that there are sex differences in play preference that are greater for blacks and for central-city residents than for whites or suburban residents. That sex differences are greater among blacks than among whites with regard to such things as self-esteem has been reported by Yarrow, Campbell and Yarrow and by Stewart. (15) (16) A recent study of the recreation preferences and experiences of high-school students by Peterson, Hanssen and Bishop also reports greater sex differences for blacks than for whites. (17) The central-city differences also have reinforcement. Kohn found that working class boys and girls have toy preferences much closer to traditional sex-typed choices than do middle class children. (18) However, the actual qualitative differences are difficult to interpret in design terms and probably have more relevance sociologically or psychologically.

Qualitative Findings-Play Environment

The children differentiate strongly between contrived and uncontrived play environments. By contrived environment, we mean that it has been designed for the purpose of play, whereas an uncontrived environment is one that might be used for play but is not intended for that purpose. These two types of environment cannot be scaled on the same continuum, which suggests that they are not equivalent and perform different functions in the minds of the children. It was found that construction sites, junkyards and vacant lots comprised one scale continuum whereas the contrived playgrounds offering conventional facilities had to be scaled on another continuum. This suggests that "adventure playgrounds" may be complements to, rather than substitutes for, playgrounds primarily designed for physical activity. (19)

In general the children preferred thematic and colorful environments, that were clearly recognizable as places to play, with an appearance of openness and an abundance of attractive vegetation. A striking difference between adults and children occurred in the case of an innovative and stylized play area without any of the conventional equipment, but obviously the recipient of careful and tasteful architectural design. This was rated very high (2nd) by the adults, but mediocre (7th) by the children. Adults and children agreed that stark, enclosed, barren, hard, cluttered or colorless areas are the least desirable.

Activity Variation

Again, colorful, innovative and thematic designs were preferred over those which are drab or traditional. In fact, the children seemed more concerned with design treatment than with the apparent activity. A traditional sandbox was the least preferred of the fifteen alternatives while an innovative sandbox was near the top of the list (fourth). The innovative sandbox added things to climb on, under and thru, however, and therefore offered much more than an opportunity to dig in the sand. The seven most preferred activities were, in order of average desirability, 1) thematic and colorful rocket ship slide, 2) geodesic dome climber, 3) traditional merry-go-round, 4) innovative sandbox, including things to climb on, under and thru, 5) innovative seesaw (4 way with springs and animals), 6) innovative swings (St. Louis-type supporting arches), and 7) innovative wading pond, including smooth rocks and stone seals. The eight least preferred activities were, in order, 1) traditional slide, 2) traditional wading pond with sprinkler, 3) traditional seesaw, 4) traditional monkey bars, 5) traditional swings, 6) innovative Lincoln logs for building, 7) cable slide and 8) traditional sandbox.

The results indicate that unusual activities such as Lincoln logs or the cable slide should be tested experimentally before they are used. The low preference ratings may be due to unfamiliarity and a resulting inability of the child to visualize himself in the situations. Alternatively, the activities may simply be less interesting or too demanding for the age group in question.

Slide Design Variation

In this set of photographs the thematic rocket ship slide that was most preferred in the activity variation study was eclipsed by four other designs. The most preferred slide had the appearance of a giant cage-like robot with the slides being tubes that are the robot's arms. In second place was a giant undulating slide with capacity for six riders in parallel. Third most preferred was an innovative spiral slide and fourth was a planet-like combined slide and climber. Only three traditional slide designs were included, and they were 12th, 13th, and 14th out of fifteen. Surprisingly, a natural mud slide on a small grassy hill was least preferred by the children. It was rated much higher (9th) by adult designers. In general, the children were attracted by an exciting ride (height, speed, variation), color, and imaginative design with an animated or dynamic and recognizable theme. Garishness seems to be more attractive than "tasteful" architectural designs, as though "stimulus-seeking" is an important motive. (20)

Climbing Design Variation

For this group of photos the disagreement between adults and children was greater than for any of the other groups. The correlation between the two scales was only 0.28 which has a probability of 0.31 of occurring by chance alone from a totally uncorrelated population. In general the adults discriminated much more strongly among the alternatives than the children did, but their criteria seemed to be totally different. The children again preferred colorful, innovative and imaginative designs. A common characteristic of three of the five most preferred is the fact that the child climbs on, thru, and into cavities in an object rather than on a frame or lattice that is the object. The two most preferred were of this type and were also very colorful.

Apparently the children studied are not as interested in trees as is commonly believed. Three of the fifteen photos had a tree theme. One was a tree-house in an artificial tree, a second was a climber consisting of tree-like structures and the third was a real tree. These were rated 10th, 12th, and 15th, respectively by the children. The adults rated them 3rd, 4th, and 8th. In addition to this problem with trees, the adults seemed to be so concerned with what might be called "artistic prejudice," that they were relatively insensitive to the criteria used by children. Again, the traditional designs (horizontal ladder, monkey bars and horizontal bars) were at the bottom of the children's list, and this is the only thing that the adults and children even came close to agreeing on. A challenging design problem is obviously to create climbing devices that satisfy the adult's aesthetic senses while also exciting the child's imagination and satisfying his need for stimulation.

Effects of Numbers

This test employed five photographs of a moderately innovative climbing device. The five pictures were identical with the exception of the number of children using the device. This was varied so that there were one, two, three, four and thirteen children. Unfortunately, there were also some shadow variations that may have influenced response, but the data do not allow this to be tested. The children preferred, in order from most to least, the pictures with three, four, thirteen, two and one child. In general the adults agreed. This shows that crowded and empty are both less desirable than three or four children playing, and that crowded is more desirable, on the average, than empty.

Summary and Future Directions

The research described briefly in this paper was designed primarily for 1) testing the validity of techniques for measuring children's preferences for playground alternatives, and 2) testing the hypothesis that adult designers are insensitive to children's preferences. The results demonstrate that photographs and the methods of rank order and paired comparison produce highly reliable and internally consistent interval scales of average preference for playground alternatives. Comparison with data obtained thru unobstrusive observation of actual playground behavior suggests that the artificially derived preference scales also have considerable behavioral meaning, but the scales are apparently less sensitive than behavioral observation.

The hypothesis that adult designers are insensitive to the play preferences of children is strongly supported by the results. This suggests that the design traditions and artistic talents of the design profession may not be sufficient. The objective of playground design is to provide attractive and satisfying play opportunities that also enhance the child's "health, safety, and morals," contribute constructively to his growth and development, and are economical. Designers must add to their skills and techniques 1) an ability to measure the preferences of children, and 2) an ability to explain the preferences in terms of design variables.

Measurement of preferences is useful in identifying and closing the communication gap, and this research has both demonstrated the need and provided a methodology. In specific cases the designer or administrator can test alternative designs using the methods we have described. Hopefully, our results will also stimulate research aimed at explaining what children prefer. An explanation of preference is necessary if synthesis of new alternatives is to be efficient. What is needed is a theory of the child's environmental preferences, in terms of real design variables.

Although the studies described in this paper were not designed specifically to describe or explain children's preferences for play equipment, some coincidental information was acquired. This information together with content analysis of the photographs will be used in the future to propose specific explanatory hypotheses.

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are present, but the supervision is usually kept to a minimum. In Europe they have been quite popular. They have not found much success in this country, however, due to adult objections on aesthetic and safety grounds. No photos of actual adventure playgrounds were included in this study, because none were available to us. Junkyards and construction sites were intended to be approximate substitutes.

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TOWARD A SET OF SEMANTIC SCALES TO MEASURE THE MEANING OF ARCHITECTURAL ENVIRONMENTS

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At the annual meeting of the Western Psychological Association last spring John B. Collins and Richard W. Seaton presented a paper in which they attempted to make some sense of the semantic dimensions emerging from a number of studies using the semantic differential (or single adjectival descriptors) to measure the physical environment. In presenting the paper, Collins admonished that too much time had been spent covering the same ground; that it was time to take stock of what had been discovered and to proceed to more directed research. In the paper the authors declared that "most of us have not even arrived at the rigor of even having hypotheses; much less evolving a set of converging alternate ones." (1)

The purpose of this paper is to present a theoretical argument and the necessary hypotheses for developing a working set of semantic scales, to "take stock" of completed work in the area, and to report on additional studies by myself directed at resolving some of the factor differences.

Theoretical Overview

Why do we need a set of semantic scales to measure the meaning of architectural environments? What important objectives can be accomplished using them which could not be as easily accomplished by other means? Why not study behavior directly in specific environments? These are the type of questions which must be at the heart of any justification of the use of semantic measuring devices. Charles E. Osgood, of course, presented the general case very well in his book, The Measurement of Meaning. (2) I will leave the continuing phenomenological versas behavioral arguments to the psychologists. However, as a practicing/teaching architect, I do have some thoughts regarding the measurement of architectural meaning. Architects, if they are to serve mankind well, must improve their abilities to predict (accurately and consistently) how people will comprehend and use the buildings which they design--before they are constructed. (3) The semantic differential and other semantic scaling devices appear to offer possibilities in this regard. Why? They correspond to the verbal mode by which occupants of buildings most often express their preceptions, thoughts, feelings, attitudes, and behaviors to architects concerning the physical environment. They are easy to administer, score, and analyze. Their validity and reliability in predicting behavior has been demonstrated in general by Osgood and a beginning has been made for architectural subject matter by Collins (1). As David Canter has stated so well:

> "...words are of interest because they are frequently predictors of actions. To say you hate a place is often a precursor to your leaving it. Another way of expressing this is that words take less force to trigger off than actions and thus are more sensitive indicators of the situation... They give insight into what is going on inside people." (6)

The crunch, however, is in prediction. How can semantic scaling devices be used to enable the architect to predict better how people will comprehend and use his buildings before they are constructed? The semantic scaling devices must give him information which he does not presently have or cannot readily obtain by traditional observation and interviewing methods...("anecdotal evidence and folklore wisdom" says Craik). (7)

Specifically the architect must obtain reliable and valid information about the relationships between the formal properties and attributes of what he designs and the thoughts, feelings, attitudes and behaviors which they tend to evoke. Description of the physical or phenomenological attributes of an environment and of the thoughts, feelings, attitudes, and behaviors associated with the environment is not enough. The architect, to design new environments (environments unlike any others previously existing, hence, not directly observable) which will maximally benefit the occupants, must know which aspects or attributes of the physical environment cause which thoughts, feelings, attitudes, or behaviors as a minimum. He should also know why if he has any desire to predict beyond the sample of population which he (or an environmental psychologist) has studied. With adequate theory (and converging hypotheses) the semantic differential and similar semantic devices can be employed to do just that: (A) to discover causal relationships between the form of the physical environment and those who occupy it, and (B) to provide a basis for understanding the WHY of the relationship. Not just any set of semantic differential scales will do. It is not enough to get ever larger and larger samples of adjectives and respondents and to "massage" the data with more and more factor analyses.

I specifically disagree with Collins that what is now needed is a "definitive and final 200+ variable study involving some 1,000 subjects..." (1) It would have no hope of being definitive or final unless (A) an equally huge and comprehensive sample of "environmental displays" were included, (B) there was some reason to believe that the representational media which would have to be employed were an adequate substitute for actual architectural environments (no basis at present), and (C) that any human subjects could sensibly respond to some 200+ "environmental displays" on each of some 200+ scales. Even if this could be accomplished there is little reason to believe that the factors obtained would be any fewer or more interpretable than the 45 or more found by Collins in his first study.

What we need is the "converging set of hypothesis" which Collins also called for...a theory which will provide a basis for the selection of specific scales, specific "environmental displays", specific respondents, and specific media types. (8) The massive correlational studies already executed using a variety of approaches to all of the above have provided the clues for such a theory--we need to exchange the broadsword for the rapier--to use brain instead of braun.

The theory which I am proposing as a beginning has been expostulated elsewhere (9, 10, 11), but can be summarized briefly here as follows:

Comprehension of the physical environment consists of two essential states: (1) The first is the representational stage. The physical environment, serving as a stimulus object, is responded to in that it, and anything to which it refers as a sign, is represented in the human organism as a precept, concept, idea, image, or whatever. We "see" the rectangular object, "recognize" it to be a door, "feel" the coolness of the bronze knob, etc. (2) The second is the responsive stage. It consists of internal responses to the already internal representations. These responses might be affective, evaluative, or prescriptive in nature: "tinglings" in our spine, "feelings" of disgust or contempt, "thoughts" about the value of the represented environment, or "ideas" concerning what should be done about it. In any case this model of meaning, or comprehension, can be likened to an internalized stimulus-response situation where our representations of the architectural environment serve as stimuli for affective, evaluational, and prescriptive responses.

If correct, the implications of this theory for developing a set of useful semantic scales are most important. Unlike the model advanced by Osgood (2), this theory states that where the physical environment is concerned there are two distinct aspects of comprehension and that the second is dependent on the first. What then are the implications?

We must seek that set of semantic scales corresponding to the attributes of the physical environment which most affect persons in that environment; and another set of semantic scales which correspond to the different ways the persons are affected. We should account for those attributes of the physical environment which "move us", which cause our hearts to palpitate, our heads to spin, our spirits to set sail or conversely to make us calm, sulky, hateful, or fearful. We should account for those attributes upon which people base their judgement of appropriateness, comfort, beauty, pleasantness, or even humor. If possible, we should account for those attributes which affect how we act; where we go, how directly, at what speed, to whom we speak, etc.

We seek on one hand a set of semantic scales which represent all meaningful aspects of the physical environment. On the other we seek a set of semantic scales which describe potential human responses to the attributes of the physical environment described by the first set. Taken together the architect can discover what he needs to know about how a specific group of users will respond to his building; if the users will "like" his building, if they will consider it comfortable and pleasant, if they will behave appropriately--with reverence, indifference, or whatever.

Searching for Sets

Specifically, then, what should characterize the set(s) of semantic scales used to describe the physical environment and our responses to it? First we should recognize the limitations of the semantic differential and similar adjectival descriptions. The adjectives should not be too specific. The variations in the environment are infinite--and hence impossible to describe completely. To have an effective general instrument we need descriptions which represent a gestalt, schemata, sets, intermediary objects. (12) I prefer to make the distinction between architectural properties (the physically measureable characteristics) and architectural attributes (those characteristics which we assign to architectural objects on the basis of our experience). The differences are subtle to be sure, but nevertheless important. For instance, an object might be square or round or triangular, etc., etc. These are properties capable of verification by standard physical measuring procedures relative to accepted external standards. If, however, an object is more complex, as all architectural environments are, such words become inadequate and certainly inaccurate. Words like angular, rounded, jagged, etc., however, are suitable because of their "intermediary" characteristics and, thus, more capable of describing the complex phenomena associated with architectural objects. Similarly, words naming specific objects or parts of objects are inappropriate because of their specificity. Words like window, door, carpet, lamp, and chair are of little interest in a design sense because they precede design. Their combination with still other elements (inter-relationships) is what interests architects. In any case their numbers are almost endless. Who could decide which to leave in and which to leave out? (13) Qualities of environments created by such objects and their combinations, on the other hand, such as crowded, cluttered, open, and light are important and capable of measurement using the semantic differential. Such words as these can be applied to many many combinations of actual windows, doors, carpets, and so on.

A second issue of considerable importance is the commonness of meanings of the selected adjectival descriptors--principally, will the users (respondents) use the descriptors to "mean" the same thing? The fact that a person with a somewhat different meaning for each descriptor will interpret the results makes error even more possible. One of the primary criticisms leveled at the semantic differential is the fact that it forces people to verbalize non-verbal perceptions, thoughts, feelings, and actions and, hence, is subject to error in the process. This is true. However, because of their wide use in all cultures, words are probably the best means we have to study perceptions, thoughts, and feelings. With respect to actions (behavior), I tend to accept the criticism and believe validation with respect to observed behavior is most important. (14) The other alternative is to find scales which demonstrably have common agreement with respect to referents for all relevant population groups. This is possible and should be done.

In summary, the measuring instrument must be general enough to apply to many environments and respondent groups with a degree of accuracy capable of useful interpretation. In terms of factor analysis, any scale chosen should have (A) the ability to detect important differences between the attributes of architectural objects for the variety of users responding to them, (B) a consistently high communality within and between all groups of potential respondents and interpreters, (C) a generally high and exclusive loading on the factor which they are to represent (to insure that all other scales normally loading on the factor are also adequately represented), (D) a demonstrated capacity to "confound" the analysis occasionally (for specific respondent groups or environmental displays) by switching primary or secondary loadings to another factor, preferably from a representational factor to a responsive factor or vice versa. (E) an ability to discriminate between architectural attributes assigned because of the characteristics of the representational media rather than because of the characteristics of the architectural object itself).

The fourth criteria (D) is perhaps the most controversial, but in some respects the most critical. Some elaboration may be helpful. This is the criteria which will enable the architect to discover the relationships between the form (significate) and the user (interpreter) -- (Pragmatics) (15). If the scales chosen were always orthogonal when factor analyzed, the result would be only descriptions of representations and descriptions of responses and no explanation about the relationships (if any) between the two. Indeed, if it were found that some representational scales never loaded with responsive scales either in factor analysis by groups or analysis of variance over "environmental displays", they should probably be discarded as NOISE since they would provide the architect with no useful information. This, of course, should not be done until all relevant sub-classes of the population and architectural environment have been studied. Some attributes of the environment might, for example, only have affects on feelings, emotions, attitudes, and behavior during puberty, pregnancy, or senility --none of which to my knowledge have as yet been studied.

Previous Studies

The most substantial research in this area has been accomplished by Vielhauer (16), Canter (6), Craik (4), Collins (4), Brittell (17), and Hershberger (9, 10, 3). Most of these were reviewed by Collins and Seaton in their paper for the Western Psychological Association (1). Their conclusions will be looked at in light of the criteria for scale selection set forth in previous paragraphs. They felt there was noteworthy agreement between all of the researchers (exclusive of Brittell who they did not review) on the first dimension which they labeled as aesthetic evaluation. A tendency to confound activity scales such as dynamic, exciting, lively, and action was noted and is of considerable importance. The second factor also appeared to be common for the six researchers. It has loadings of such scales as neat, orderly, tidy, clear, stable, calm, etc. Again they noted a tendency to confound orderly, tidy, neat with simple, rational, straightforward.

A third space factor was evident for four of the six researchers, but was broken into separate factors (phenomenological size: roomy, spacious, open, uncrowded and physical size: large, high, big, wide) for some and for Hershberger confounded into the first factor. Other factors were found in common for some but not for others as follows: Vielhauer and Collins both reported factor(s) relating to temperature/ventilation and to lighting. Hershberger reported a potency dimension which was confounded with his aesthetic dimension. (18) Janiskee and Canter reported a texture factor with scales of course-fine and rough-smooth. Collins and Craik had a shape factor composed of scales such as elliptical, cylindrical, knotted, conical, and globular.

They point out that the number of scales used by the various researchers (Vielhauer 66, Canter 50, Hershberger 30, Craik's EADCL 120, Collins 142, and Janiskee 22 or 454 items less those used in common) and indicate that "quite a reasonable pool of probable items has been developed." I agree, but with a note of caution. In my own studies some of the factors did not emerge simply because there were no appropriate bi-polar adjectives to allow them to emerge. I suspect the same was true for Vielhauer, Canter, Craik, and Janiskee, if not Collins. On the other hand I suspect that other factors did not emerge for some of the researchers because of extremely limited "environmental displays" as for instance with Collins, Canter, and Vielhauer...interiors of campus buildings, offices, and houses are generally not the most "potent" examples of architecture. I especially expect this to be true at the U. of U. and L.S.U. Be that what it may, together I believe the studies suggest quite a number of relevant scales to represent the architectural environment and responses to it.

My intention now is to briefly scrutinize Vielhauer's study to demonstrate some important confounding effects. This could equally be done with my own studies, but they are already reported elsewhere (3, 9, 10). Taking Vielhauer's study and comparing three of the factor structures shown in TABLE I, it can be seen that orthogonal factors for one building will not necessarily be orthogonal for another. This is important! For example, the distinct COLORING factor accounting for 14.48% of the common variance with high exclusive loadings of such scales as bright-dull and colorful-drab for the Plantation Room (which was orthogonal to the more general AESTHETIC APPEAL factor accounting for 21.97% of the variance) was absorbed into the more general AESTHETIC APPEAL dimension accounting for 27.73% of the common variance for the Geology Auditorium. Did the AESTHETIC APPEAL factor for the two buildings really change or was the Geology Auditorium dependent on its bright coloration for its aesthetic appeal? Were the bright colors more than usually responsible for the building's appeal?

Comparing the last LIGHTING factor accounting for 5.32% of the common variance on the Geology Auditorium with the lack of such a dimension for the Plantation Room, we find soft lighting (one of the two scales comprising the LIGHTING factor) loading at .70 on the General AESTHETIC APPEAL factor. Could it be that some of the appeal of the Plantation Room is due to its lack of bright, colorful, gay, flashy colors, indeed, due to its having soft lighting? In any event it is likely that bright colors on one hand and soft lighting on the other should not be considered Evaluative in nature--rather to be representational. Similar arguments could be made with respect to the CLEANLINESS factor found for the Geology Auditorium which is confounded with the PHYSICAL ORGANIZATION factor particularly of the Reserve Reading Room. Would it be possible for some room to have its cleanliness but not its organization scales confound with its Aesthetic Appeal? I think so.

Similar confounding of factors were found by Canter (6) with regard to space in offices. He found an "aesthetic" dimension with high loadings of such words as dignified, beautiful, pleasant, and spacious; he also reported a friendliness dimension with such words as cozy, safe, pleasant, and friendly; and a final factor with scale loadings of private, personal, and small. In this case some aspect of the usual SPACE dimension confounded with each of the other dimensions--and logically so!

My own studies have provided even greater evidence of the importance of the "confounding" of representational and responsive scales. The Pennsylvania and Drexel architects in my dissertation study, for example, tended to confound potency scales (bold, strong, rugged, permanent) with aesthetic scales (unique, active, revolutionary, profound, exciting) indicating for them that almost any building (they rated 24 widely ranging buildings including exteriors, entrances, and interiors) must be extremely potent if it is to be aesthetically satisfactory. The pre-architects and non-architects in the same study did not respond in the same way. They tended to confound the space scales (spacious, open, loose) with both the evaluational and the aesthetic scales, indicating, perhaps, that if a building were seen to be spacious it would be considered both exciting and pleasant. The Penn. architects and Drexel architects confounded the space scales only with the evaluation scales. For the Drexel architects such scales as beautiful-ugly, comfortable-uncomfortable, and good-bad loaded highly and positively with the organization scales, indicating that the Drexel students consistently attributed beauty, comfort, and goodness to those buildings which they considered to be rational and clearly organized. Further analysis of the same data using oblique rotational criteria and revealing factor correlations tended to verify the hypotheses by demonstrating that the Organization, Potency, and Space dimensions were in fact completely orthogonal while the Aesthetic and

TABLE I[b]	A Reserve Reading Room		B-1 Plantation Room		C-1 Geology Auditorium	
I. Aesthetic Appeal	(17.49)[a]		(21.97)		(27.23)	
	Pleasant	.84	Attractive	.76	Beautiful	-.78
	Gay	.75	Soft Lighting	.70	Gay	-.77
	Colorful	.62	Stylish	.68	Attractive	-.76
	Cheerful	.60	Inviting	.67	Cheerful	-.74
	Inviting	.57	Impressive	.65	Colorful	-.72
	Comfortable	.52	Fashionable	.62	Elegant	-.69
	Sparkling	.51	Beautiful	.62	Impressive	-.66
	Style (12.80)		Good colors	.61	Tasteful	-.63
			Modern	.61	Stylish	-.63
	Stylish	.66	Good lines	.55	Fashionable	-.62
	Fashionable	.60	Distinctive	.50	Bright	-.55
	Good lines	.60	Coloring (14.48)		Sparkling	-.55
	Impressive	.50			Good colors	-.54
	Functional (8.75)		Bright colors	.84	Ornate	-.52
			Bright	.75	Pleasant	-.52
	Functional	.66	Colorful	.72	Flashy colors	-.51
	Quiet	.53	Gay	.72		
	Beautiful	-.52	Flashy colors	.65		
	Distinctive	-.50				
II. Physical Organization	(15.07)		(13.50)		Organization (15.68)	
	Neat	.77	Well organized	.74	Good ventilation	.84
	Orderly	.70	Tidy	.66	Well organized	.75
	Well kept	.67	Orderly	.63	Efficient	.69
	Well organized	.65	Neat	.59	Orderly	.68
	Efficient	.64	Organized	.59	Organized	.65
	Tidy	.59	Well kept	.57	Well planned	.54
	Organized	.57			Cleanliness (9.09)	
	Clean	.56			Clean	-.78
	Uncluttered	.55			Tidy	-.63
					Neat	-.61
					Fresh odor	-.52
III. Size	(11.18)		(12.89)		Phenom. Size (8.47)	
	Large	.83	Roomy	-.76	Roomy	-.79
	Huge	.65	Large	-.72	Free space	-.68
	Wide	.63	Adequate size	-.66	Uncrowded	-.64
	Roomy	.62	Free space	-.64	Comfortable	-.58
	Adequate size	.57	Huge	-.62	Physical Size (6.18)	
	Free space	.50	Wide	-.61	Large	.68
					Huge	.66
IV. Temperature-Ventilation	(12.53)		(7.81)		(10.94)	
	Good temp.	.78	Good temp.	.77	Good temp.	.85
	Comfortable temp.	.75	Comfortable temp.	.64	Good ventilation	.84
	Drafty	.72			Comfortable temp.	.81
	Warm	-.71			Drafty	.72
	Fresh odor	.51			Warm	-.61
V. Lighting					(5.12)	
					Diffuse lighting	.53
					Soft lighting	.50

[a] The percentage enclosed in the parentheses after each factor indicates the percent of common variance accounted for.

[b] The three factor structures are taken from J. A. Vielhauer's dissertation, The Development of a Schematic Scale for Description of the Physical Environment.

Evaluational factors were not. These factors often had correlations with one or another of the independent factors and with each other. It is hypothesized here that the same will be true for these responsive factors and still other representational factors.

Recent studies by the author at Arizona State University with pre-architects and psychology students (male and female) have revealed similar relationships. Here, however, scales indicating novelty and affect such as profound, unique, active, interesting, and exciting which had loaded positively on the Potency Dimension for the Penn. architects switched over and loaded negatively on the Organization Dimension. Students at Arizona State University apparently are affected aesthetically more by complexity and ornateness than by ruggedness and permanence.

The point in any case is that it should be expected that certain key attributes of the architectural environment will have major affects on the aesthetic and evaluational responses of some respondent groups. If one such attribute consistently takes priority then it will show in the factor structure itself and rightly so. It need not, however, to be useful. There are, perhaps, combinations of orthogonal representational factors which taken together will consistently predict aesthetic or evaluative responses for some respondent group or category of "environmental display". Such relationships can be demonstrated using analysis of variance comparisons between respondent groups over "environmental displays" or vice versa.

Analysis of the factor analytic studies previously mentioned (summarized on TABLE II) indicate a potential of approximately fifteen representational factors (eliminating nominal and purely denotative descriptors) and two to four responsive factors. The original studies by the author at Pennsylvania and those recently completed at Arizona State University tend to coroborate the first five factors: AESTHETIC, FRIENDLINESS, ORGANIZATION, POTENCY, and SPACE as well as give further support to the existence of a LIGHTING factor. In addition they indicate a strong and independent ORNATE/COMPLEX factor for the pre-architects standing side by side with the more usual ORGANIZATION factor. Interestingly this did not occur for the psychology students, for whom these scales remained with the AESTHETIC factor.

Reasonably singular or weak factors also appeared in these studies when an additional 30 scales were added to the response format. These factors include a RIGIDITY or TAUTNESS factor and a SIZE/FORMALITY factor both of which correspond to factors appearing in some of Osgood's studies. Another FULLNESS factor may relate to the Phenomenological Space or the Neatness factors of the other studies. Finally in one or more of the several analyses conducted in this study the following factors occurred: OBVIOUS, PROUD, RATIONAL, REVOLUTIONARY, UNIQUE, MASSIVE, and FLOWING...usually as single loading factors. Subjecting these to a test for communalities, several scales reveal themselves to have considerable communality while others tend to have very little indeed. This can be seen in TABLE III which summarizes the communalities by scale over all of the factor analyses conducted at A.S.U. (the numbers for the first 30 scales are higher due to their more extensive use).

Scales revealed as probably unsuitable for general use have one or more instances in which the communality has dropped below forty and several instances into the forties and fifties. The most pronounced cases are rational-intuitive, superficial-profound, continuous-broken, revolutionary-reactionary in the first set and subtle-obvious, soaring-settling, flowing-articulated in the second set. The factors depending on these scales probably should be considered spurious and eliminated from factor consideration. Similarly, since the UNIQUENESS factor appeared only for black and white slide representation, where a distinct aesthetic dimension failed to appear, it is likely the result of the media of presentation than of the respondents or "environmental displays". Likewise, whenever both sets of scales are used together (60 total) the massive and rugged scales tend to load together on a common POTENCY factor. This leaves only ORNATE/COMPLEX, FULLNESS, LIGHT/DARK, SIZE/FORMALITY, and RIGIDITY potentially new factors. As noted before, all have some correspondence to factors which have appeared in other studies using the semantic differential.

Toward a Set of Descriptors

Five strong dimensions of architectural meaning are now well established: (1) Aesthetic, (2) Friendliness, (3) Organization, (4) Potency, and (5) Space. Several other factors have been in evidence in enough studies that they too should be included: (6) Ornate, (7) Coloring, (8) Neatness, (9) Size, (10) Temperature, (11) Lighting, (12) Privacy, and (13) Shape. Although in evidence only in Collin's work, it is also essential to include the (14) Ventilation and (15) Noise factors because of their relevance to architecture and the complete failure of the other researchers to include these scales in their studies. The (16) Rigidity and (17) Formality dimensions should, perhaps, also be allowed because of their relationshio to Osgood's work, although on close inspection of factor loadings they consistently seem to confound with each other and a potentially independent Size factor. Canter's (18) Rough/Course /Dark factor seems to be sufficiently different from Hershberger's Strong, Rugged, Permanent, Massive factor that it might also warrant repre-

TABLE II TYPICAL FACTOR STRUCTURES OF SEMANTIC DESCRIPTORS BY SEVEN RESEARCHERS

Factor			Researcher				
	Vielhauer	Center	Craik	Collins	Janiskee	Brittell	Hershberger 69 and 71	
1 AESTH		impressive interestg unique	different dynamic interestg	expressive unique interestg	interestg beautiful impressve	inspiring attractive exciting	unique exciting interestg	unique interesting exciting
2 FRIEND	beautiful attractiv appealing	soft friendly welcome	civilized cheerful joyful	happy joyful fun			spacious cheerful comfortab	friendly soft comfortbl
3 CRGAN	organized efficient orderly	tidy coherent clear		Equipped Coordind complete		ordered balanced simple	controlld ordered clear	ordered controlled clear
4 POTEN/ TEXTURE 18 UTILITY 20		rough 18 course dark			rough course 18		rugged permanent strong	rugged massive permanent
5 SPACE	roomy large wide	flexible changeable spacious		liveable lived in curtained	near central accessibl	open light		spacious large loose
6 ORNATE/ COLOR	bright colorful gay		conservtb colorful bizarre	textured bright C. flashy			complex ornate	generous rich lavish
8 NEAT	clean tidy neat		dirty empty broad	cluttered confined roomy				
9 SIZE FORMAL 17	large huge		big huge broad	big large roomy		high vertical tense		large 17 formal proud
10 TEMP	comfort drafty warm			heated breezy new				
11 LIGHT	diffuse soft L.			airy light open				
12 PRIVACY		protected saft		secluded private safe				
13 SHAPE/ TEXTURE 18			eliptical cylindrcl globular	geometric wide diagonal				
14 VENT				airy fresh ventilated				
15 NOISE				grey quiet brown				
16 RIGID/ TIME 19 UTILITY 20			convenient accomod 20 layout	constant stable 19 calm				

TABLE III PREFERRED SCALES*

FACTORS AND SCALES	No. of HIGH EXCL. LOADINGS		No. of SHARED LOADINGS		No. of COMMUNALITIES
	Same Factors (over .60)	Other Factors (over .60)	Same Factors (over .40	Other Fac. over .40)	(< .50 <)
AESTHETIC					
Simple	11	Ornate 2	1	6,2	0/3
Active	12	Ornate 1	5	4,4	3/10
Strong	4	Poten. 4	10	4,6,3	0/1
Unique *	12	Ornate 1	5	4,7	0/0
Exciting	13	0	6	2,3,4	0/10
Ornate	10	Ornate 6	2	1,1	0/4
Interesting	6	Eval 1	16	15,3,2	0/0
Specialized	11	Misc. 2	7	4,8	4/13
Bold	5	Poten 2	9	10,1,2	0/1
Revolutionary	4	Misc. 3	0	1,1	20/11
Dynamic	5	0	2	1,1	0/5
Rich	5	Rich 1	1	3,2,1,3	0/0
Special	8	0	4	1,3,1,1	0/0
Soaring	6	0	1	1	2/10
Lavish	5	lavish 1	5	1,7	0/1
Witty	7	0	6	6	0/0
Individual	5	0	3	2,2	0/7
FRIENDLINESS					
Beautiful	5	0	16	12,1,3	0/0
Good	5	0	16	15,4	0/0
Cheerful	4	0	12	12,5	0/0
Welcoming	10	0	11	7,2,3	0/0
Comfortable	11	0	8	3,1,3	0/1
Delightful	4	0	19	12,4	0/0
Pleasing	8	0	11	10,3	0/0
Graceful	4	Misc. 2	4	1,3	0/0
Sensible	4	Misc. 2	5	5	0/0
Soft	6	Misc. 2	2	2	0/2
Passing	4	Aesth 1	6	5,1	0/1
Warm	8	0	4	2,1	0/0
Friendly *	8	0	4	1,1,1,2	0/0
Natural	4	Aesth 1	0	0	0/10
ORGANIZATION					
Rational	4	Poten 1	1	1	24/5
Clear	15	0	2	2	8/17
Controlled	18	0	1	1	3/11
Ordered *	17	0	2	1,1	0/2
Continuous	6	0	5	1,1,1,1	24/6
Considered	14	0	4	2,2	3/14
Straight fwd.	13	Spur 1	3	3	5/18
POTENCY					
Strong	4	Aesth 4	6	10,4,3	0/1
Rugged *	20	0	2	2,2	1/6
Permanent	11	0	3	1,1,1	9/16
Massive	9	Misc. 2	1	1	0/2
SPACE					
Spacious	10	0	7	2,7	5/7
Open	10	Eval. 1	8	3,9	5/9
Loose/tight	5	Misc. 3	4	1,5,1	0/10
Large	6	Large 1	4	1,3,1	0/0
Loose/compact *	10	Poten 1	2	1,1	0/2

*Asterisks indicate the preferred scale based on the number of high exclusive loadings over .60, the shared loadings over .40, and communalities <.50<. Scales separated by a short underline are from the reduced number of studies using the revised set of scales.

sentation as an independent variable. Likewise Janiskee's factor consisting of scales such as constant, stable, calm, inflexible have a sufficient notion of time connected with them that they might be better grouped as an independent (19) TIME factor. Relating to the work of Craik and Collins we might entertain a third (20) Utilitarian/Functional factor to round out the responsive factors at three and the representational factors at seventeen.

Begging to differ with both Osgood in his search for three and Collins in his search for seven plus or minus two, I feel seventeen representational scales and three responsive scales are (along with Venture) "almost just right" owing to the complexity and diversity of the material to be studied. Indeed, for a start they are excellent. Repeated factor analyses of the 20 scales for subsequent studies will reveal if some of the representational scales consistently load together. If so then a logical reduction can be made which is based on the evidence at hand and not for the sake of brevity...false parsimony!

Testing scales consistently loading highly and exclusively on the six most dominant factors against communalities and occasional loading with other factors in my own studies as shown on TABLE III, I found the following scales to represent the first six factors:

1. AESTHETIC: Unique-Common
2. FRIENDLINESS: Friendly-Hostile
3. ORGANIZATION: Ordered-Chaotic
4. POTENCY: Rugged-Delicate
5. SPACE: Loose-Compact
6. ORNATE: Ornate-Plain

With regard to the remaining scale selections, I have based my selections when possible on the first combination of high factor loadings and to the "395 Descriptors of Interior Home Environments" by 102 students set forth in Collin's doctoral dissertation (4). The criteria are to match poles and pairs in order of factor loading and "decreasing frequency of occurrence" on the descriptors. The assumption here is that demonstrated high factor loading and frequency of word use is a valid way (short of knowledge of communalities) to select appropriate scales. The remaining scale selections for factors, therefore, are as follows:

7. COLORING: Colorful-Subdued
8. NEATNESS: Clean-Dirty
9. SIZE: Large-Small
10. TEMPERATURE: Warm-Cool
11. LIGHTING: Light-Dark
12. PRIVACY: Private-Public
13. SHAPE: Angled-Curved
14. VENTILATION: Drafty-Stuffy
15. NOISE: Quiet-Noisy
16. RIGIDITY: Rigid-Flexible
17. FORMAL: Formal-Casual
18. TEXTURE: Rough-Smooth
19. TIME: Old-New
20. UTILITY: Useful-Useless

The above listed set of twenty scales is a beginning step towards a definitive set of semantic scales to measure the meaning of architectural environments. It takes into account all of the best research accomplished to date. It relates to a theory of meaning set forth herein and stands as a hypothesis that there are seventeen important representational dimensions of architectural meaning on which three equally important responsive dimensions may well depend. In any case, we have an hypothesis based on the aforestated theory of meaning and the practical needs of the architectural profession. Is the hypothesis correct? It can be tested.

NOTES

1. Collins, J. B. and Seaton, R. W., "Semantic Dimensions as Architectural Discriminators (How do we say what we see?!)," 1971 (unpublished).

2. Osgood, C. E., Suci, G. J., and Tannenbaum, P. H., The Measurement of Meaning, 1967.

3. Hershberger, R. G., "Predicting the Meaning of Designed Environments", 1971 (unpublished).

4. Collins, J. B., Perceptual Dimensions of Architectural Space Validated Against Behavioral Criteria, 1969. (Dissertation).

5. Maslow, A. H. and Mintz, N. L., "The Effects of Aesthetic Surroundings I & II", Journal of Psychology, 1956.

6. Canter, D., "The Study of Meaning in Architecture", 1968 (unpublished).

7. Craik, K. H., "The Comprehension of the Everyday Physical Environment", A.I.P. Journal, January, 1968.

8. The problem with nearly all of the studies thus far completed has been the lack of a theoretical overview to guide in the selection of scales, environmental displays, respondent groups, and media types. For example, only in my work has their been a conscious attempt to obtain a comprehensive sampling of "environmental displays". Can we make a useful general tool based on a few campus buildings? I think not.

9. Hershberger, R. G., A Study of Meaning and Architecture, 1969. (Dissertation).

10. Hershberger, R. G., "A Study of Meaning and Architecture", EDRA I, 1970.

11. Hershberger, R. G. "Architecture and Meaning" Journal of Aesthetic Education, 1970.

12. Norberg-Schulz, C., Intentions in Architecture, 1965 (pp 60-64).

13. If an architect is concerned about specific objects in the environment he need not use scaling devices at all. He need only ask the user to enumerate or check off the objects he wants or does not want. If, however, the interest is the quality of an object (architectural or whatever) the matter becomes relative and scaling techniques become appropriate.

14. Appleyard, D. and McKechnie, G. E., New Directions in Environmental Assessment: 1971.

15. Morris, C., Signs, Language and Behavior, 1955 (p 217).

16. Vielhauer, J. A., "The Development of a Semantic Scale for the Description of the Physical Environment", 1965 (Dissertation).

17. Brittell, D., The Connotative Meaning of Architectural Form, 1969 (Thesis).

18. This is a correction of their paper which incorrectly indicated confounding with a "goodness" dimension.

AN INVESTIGATION OF THE RELATIONSHIP BETWEEN CONSTRUING OF THE ENVIRONMENT AND ITS PHYSICAL FORM

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This paper deals with an attempt to establish a connection between people's patterns of environmental evaluation and the physical characteristics of "room or building scape."

For instance, in considering an interior how are we able to explain which of its aspects are responsible for it being praised by one group of people, rejected by another, thought warm and friendly by a third, cold and bleak by a fourth and so on?

It seems reasonable to propose that environments are a complex series of relationships and components interacting with each other. The components are not always obvious. Sometimes they may be totally indescribable within the terms of one set of references and very easily defined and explained within another. Similarly their interactions and interrelationships may be confused, subtle, blatent, complex and straightforward, all at the same time, depending upon how it is being looked at and by whom.

It may be argued that it would be artificial for the researcher to isolate any single aspect or characteristic for deep study and then expect his findings to have satisfactory relevance in explaining the evaluation of a cohesive whole environment. He would be presuming that the aspect he selects for study was significant in other people's evaluation processes. It would also be denying the contributory role played by the aspect in conjunction with all the other aspects.

Very little seems to be written about how people look at and construe environment, which aspects and which relationships between features are significant in their evaluations. This study explores one possible approach. It relies heavily on Kelly's "Psychology of Personal Constructs" (Kelly 1955) and on some of its developments. It attempts to apply construct theory in the environmental context, hypothesising that a psychological theory which primarily relates to a personal approach to personality problems can also relate to environmental evaluation.

Introduction to the Psychology of Personal Constructs

George Kelly went to practise psychology in an area of the United States remote from the established centres of the psychiatric therapy. Having to proceed without the ready availability of consultants he gradually developed his own theory (Slater 1969). His earlier education in engineering may have been the reason for the way that his own personal observations were almost "designed" together to form a psychological theory. Kelly felt that man was capable of being his own "scientist." He seemed to resent the fact that psychologists and psychiatrists were inclined to place their subjects or patients under the 'proverbial microscope,' exposing them to various test situations in order to make "wise diagnostic judgements" about them. Kelly believes that man differs from all other living organisms in that he has the facility to make sense of the world for himself. He considered that human beings were ever endeavouring to understand their experiences and that their behaviour was much more than a series of reflex instincts resulting from various life supporting requirements. Each and every experience as it is absorbed by the person is construed in the light of previous experiences, expectancies and anticipations until it "makes sense." (Bannister 1969). Kelly calls this process construing and the things or ideas which are construed "constructs." When these constructs are verbalised then the words which are used to describe these constructs are called "construct labels." An example of this construct label was provided by one of the informants in this study, who was construing living rooms. Reflecting upon a certain quality which he felt and understood very well but couldn't verbalise, he said "there are no chromium cocktail shakers." Now "no chromium cocktail shakers" could be said to be a construct label for an idea or feeling which acknowledges and appreciates the absence of bright, flashy, jazzy objects.

One of the corollaries of Personal Construct Theory states that "A person's construct system is composed of an infinite number of dichotomous constructs" (Kelly 1955a). This means that all constructs have two poles - they are bi-polar and can be thought of as a dimension running from one pole to the other. For example, in considering 'heat' the dimension may be "hot" - "cold." Ice obviously relates to the "cold" pole and "fire" to the "hot" pole.

Kelly felt that if people made sense out of their experiences and the world about them then perhaps this was a line worth following in the treatment of personality disorders. He evolved a system of construct eliciting and subsequent application which enabled his patients virtually to study themselves.

It seemed reasonable to adopt this kind of ideology to the study of environment. Human beings turn "accommodation" into "homes." They make sense out of an interior, add to it, decorate it, until they turn it into something which matches their construing of the idea of the particular room and its use. Stringer has talked about man the architect being Kelly's man the scientist in a personal environmental situation (Stringer 1969). Man the architect makes sense of his surroundings, in other words endeavours to make his surroundings fall into some kind of line with his patterns of expectancy and anticipation for them.

Kelly suggests that in order for someone to construe an experience it must fall within the range of convenience of his constructs. If something should happen to someone which is beyond the range of his convenience then anxiety and often hostility result (Kelly 1955). This same idea may be transplanted to the environmental sphere. It is often said by people "Idon't care what kind of house I live in as long as its warm and dry." One could assume, therefore, that if the house was not warm or dry it would be unsuitable. It is interesting to speculate whether in fact this person means that he would accept any house. The very fact that he says he doesn't mind what kind of house he is forced to live in Probably means that he doesn't mind what kind of house it is within the range of convenience of his construct 'house.' He would probably be most unwilling to live in a 'sardine tin' even were it large enough to accommodate him. If the house was not warm and dry it would be unsuitable but this would be within his range of convenience because he has acknowledged warmth and, therefore, lack of warmth and would be prepared to implement the necessary repairs to make it warm if it were not. He would, therefore, not become anxious because a lack of warmth and dryness would be within his range of convenience. A 'sardine tin' however would probably generate anxiety because it was not included within the range of possibilities when he made his initial statement.

With these thoughts in mind the initial work in this study was an attempt to describe the assessment and meaning of various ideas or concepts (abstract elements) associated with house and home along a limited series of dimensions. In other words certain ideas, such as living room, cottage, town house, were graded in terms of 25 descriptive dimensions or rating scales. The next step was to use the same rating scales in assessing various pictorial examples (pictorial element) of these initial ideas.

One of the environmental ideas was "living room" and its assessment was compared with four pictorial examples (elements) of living rooms. The ratings accorded to one of them (now called element 2) were similar to those given to the abstract element. The ratings given to the other three pictorial elements differed from this to varying degrees.

The sample tested consisted of 20 people selected from four employment groups but despite this small sample the unanimity of the evaluation was surprising. The reasons for the emergence of element 2 as the "best living room example" were not evident in the results (Honikman 1970). It was not possible to establish rational links between constructs or groups of constructs and the physical characteristics of the elements. As explained in the introductory paragraphs, the study of these links or relationships, without particularising or extracting any single characteristic for individual study, was the main objective of this work.

Further investigation was necessary and it was decided that element 2 should be the main vehicle for subsequent experiments.

Further Delvings into Construct Theory

Various applications of rating scales have been instrumental in many interesting studies and one has only to look to the work of, for example, Herschberger and Collins in America, Wools, Canter, Acking and Küller in Europe to gain a pretty fair understanding of the progress that has been made in the use of various construct rating methods in environmental evaluation.

Unfortunately, these studies did not provide much help. They tended to fall into two categories. The first category included studies which dissected an environment and explored one individual aspect of it and the studies in the second category investigated comparisons of environmental response between different people or groups (Honikman 1971).

Further examination of Kelly's writings about the nature of constructs and of other subsequent work seemed to offer an opportunity for at least a beginning in realising the main objective of the study.

Kelly's fundamental postulate that "a person's processes are psychologically channelised by the way in which he anticipates events" is formally set out with its eleven corollaries. Most of these are summarised in the introduction to Personal Construct Theory (see page 6-5-1)but the organisation corollary (No.3) is particularly important to the arguments that follow.

> "Each person characteristically evolves for his convenience in anticipating events, a construction system embracing ordinal relationships between constructs."
> (Kelly 1955b).

This corollary suggests that constructs interconnect with each other to form networks and systems. It is reasonable to assume that within any system or network the constructs relate to themselves and to the system as a whole with differing degrees of importance, forming hierarchies.

In their book "The Evaluation of Personal Constructs" Bannister and Mair refer to the work of Hinkle, who contended that "construct definitions must involve a statement of the location of a construct dimension in the context of a hierarchical network of construct implications (Bannister & Mair 1968). Hinkle noted that Kelly had originally explained that constructs had a hierarchical relationship with each other; some constructs include others as components contributory to their overall context. For example, the graduate of the Beaux Arts architectural tradition might construe a building as being a "fine piece of architecture." If he were asked what evidence or on what basis does he say that it is a fine piece of architecture he may say that "it has balanced proportions." It may have other qualities such as "delicate detailing" and "natural textures." Each of these are subordinate constructs within the overall context of the superordinate construct, "fine architecture." Conversely one may ask a designer why he is trying to evolve "an efficient circulation system" and the answer would probably be in order to make it a "fine building" or "fine piece of architecture." A superordinate construct will have been elicited by using subordinate constructs. In this way one is able to identify hierarchical construct systems and see how each construct links with the next until it makes up a whole construct system or network. Hinkle called this process "laddering." He noted that earlier work on the formation of concepts had tended to treat them all as being equal and look at them as though they were simply different but adjacent categories. To an extent this is characteristic of much environmental research and dissatisfaction with work which investigated 'colour' or 'form' separately, has been expressed.

If the environment could be considered as a whole concept then the various aspects of it could be considered to be working with each other in a way rather like an hierarchical system of constructs. If this were so it would be reasonable to expect that people would construe environments as hierarchical networks and that the physical features or characteristics of that environment would, for the individual observing the environment, become constructs with hierarchical relationships with each other.

Implications

Hinkle was interested in the implications which existed between subordinate and superordinate constructs. Having established that a subordinate construct was one element in the overall context of a superordinate construct it could be stated that superordinate constructs had a greater number of implications than subordinate constructs. We have already discussed how subordinate constructs such as "good detailing," "balanced proportions" and other aspects of architecture combine to form the superordinate construct "fine architecture". "Fine architecture"in turn implies "good detailing" etc., but the converse is not necessarily and inevitably true. "Good detailing" or "balanced proportions" as single subordinate constructs do not necessarily or inevitably imply "fine architecture." Bannister points out how the implications between constructs have a great similarity to categories in traditional logic. Everyone knows that a canary is a bird but a bird is not necessarily a canary.

Although Hinkle dealt with the various forms of implications which held good between constructs he decided to devote his attention to parallel and reciprocal forms. The parallel implication between two constructs is one in which the first pole of the first construct implies the first pole of the second construct and the second pole of the first construct implies the second pole of the second construct. For example, the two constructs 'love' - 'hate' and 'pleasantness' - 'unpleasantness' are parallel because 'love'implies 'pleasantness' and 'hate' implies 'unpleasantness.' In this example 'pleasantness' does not, however, imply 'love' nor 'unpleasantness' 'hate' and, therefore, the construct is not reciprocal. An example of reciprocally implicated constructs is : 'nervous' - 'calm,' 'tense' - 'relaxed.' In a pair of constructs where parallel implications exist it is reasonable to assume that the first pair is superordinate to the second. If,however, reciprocal implications exist each construct may have a similar hierarchical status within the same or within different contexts. The question of identifying the context in which constructs are operating is extremely important. The construct 'comfortable' - 'uncomfortable' may directly imply 'soft upholstery - hard upholstery' in the context of furniture. In the context of calm, friendliness in the "personality" of an interior, these two constructs may not be so directly implicated. Relationships may exist between contexts and Hinkle calls these trans-contextual implications.

The following example indicates the opportunity provided by the understanding of trans-contextual implications for sorting out the interacting influences of environmental constructs without dissecting the environment being studied. If in the first context constructs a,b. and c. imply 'comfort,' 'comfort' implies 'chairs,' 'space' and 'airiness' whilst in the second context constructs a, d. and e. imply 'comfort' and in that context 'comfort' implies 'chairs,' 'fireplace' and 'books' then the trans-contextual identity of 'comfort' is a. and chairs. Now if the two contexts being considered were firstly physical forms and secondly relaxation, we are able to suggest that 'comfort' plays the 'chair' role in each of them.

The importance or degree of superordinacy of any construct within the overall network depends on its degree of resistance to change. We have already seen that the more superordinate a construct is the greater the number of subordinate constructs implied by it. If the construct is superordinate in the true sense of the word then it is unlikely that it will change even though some of its subordinate constructs do. For instance, if a room is construed as being 'intimate' on an 'intimate-public' construct and the subordinate constructs within the 'intimate' context are 'personal,' 'enclosed,' 'chairs grouped at fireplace' and a 'pleasant place to read,' then it is clear that a change in any one of the subordinate constructs - the removal of the 'fireplace' for instance would not necessarily prevent the interior from continuing to be 'intimate' and not 'public.' If, however, one of the subordinate or apparently subordinate constructs did prevent the room from being construed as 'intimate' then it may be reasoned that for the particular observer the apparently subordinate construct was, in fact superordinate to the intimate-public construct in that a change in it was less acceptable than a change from 'intimate' to 'public.' Hinkle's argument, which supports and indeed is a basis for this reasoning, uses Kelly's Organisation corollary as a starting point. Bannister reports as follows: "Hinkle argued that the higher in the hierarchy any construct is placed the greater the number of constructs which will be needed to define its further implication, that is to say, it would have a greater range of subordinate and superordinate implications." From this he argued that "there will be a higher level of resistance to change on superordinate constructs because any change at this level will necessarily involve a great number of related changes and a considerable risk of the development of inferential incompatibility within the system." For example, it is easier for an architect to accept that he is a 'poor draughtsman' as opposed to an 'excellent draughtsman' than it is for him to accept that he is an 'inadequate designer' as opposed to a 'talented designer.' The extent of the implications of being a 'poor draughtsman' are easily envisaged and reasonaby limited whereas the extent of the implications of being a 'poor designer' are considerable and far reaching. In order to accept the notion that he is a 'poor designer' an architect would have to change radically almost all the constructs involved in his entire network of construing the role of being an architect. Returning to an environmental example, if 'intimacy' is a superordinate construct in the overall context of construing living rooms, the acceptance of a 'public' (not 'intimate') living room may imply the acceptance of change in an inordinate or unreasonable number of subordinate constructs. Hence the living room is unacceptable. According to Kelly, hostility occurs when people find that they cannot accept what amounts to an invalidation of their expectancy. Acceptance would imply a change in so many related constructs that the entire network would become disorganised, resulting in chaos. (Bannister & Mair 1968a) (Hinkle 1965).

Construct eliciting and repertory grid techniques enable the identification of individually relevant constructs and also the extent to which they apply to a given element. We can ascertain how an informant regards a 'living room' and through which channels he responds to it. 'Laddering,' 'resistance to change' and 'implication grid' techniques provide indications of the hierarchical status and interconnection of constructs.

The subordinate constructs often include or consist of the physical aspects of an environment so that it may be argued that their relationships within the contexts and construct networks link specific physical properties to an overall environmental evaluation.

Using these ideas as a basis the following seemed a sensible procedure for deeper study of the living room example.

Main Experiment

1. Construct Eliciting: Reference to a number of interior design picture books in the Polytechnic library provided a selection of colour pictures of living rooms. These, together with 2 of the living room examples from the first study, formed the elements for eliciting personal constructs of living rooms from each of the informants. Kelly's eliciting procedure involves the subject's identification of a number of people who figure or play roles in his life. Selecting 3 of these people the subject is asked to give a reason why 2 of these people are similar and different from the third. (Kelly 1955).

   The set of living room pictures was used instead of the people and subjects were asked to give reasons why they thought that two of the pictures were similar and different from the third. Element 2 was included in each trio of living room pictures used in the eliciting process.

   Care was taken not to include any constructs which appeared to be repetitions of previously elicited constructs. For example, if a subject had identified two of the living rooms as old fashioned and different from the third because it was 'modern' then if in the next trio the informant used the construct 'contemporary-period' he was questioned to see whether 'contemporary-period' was a construct with a meaning similar to 'old fashioned - modern' and if it had then it was not used as a superordinate construct. This construct eliciting process established between ten and fifteen constructs for each informant and of these the ten most clearly significant and discrete were selected for use in the later repertory grid stage.

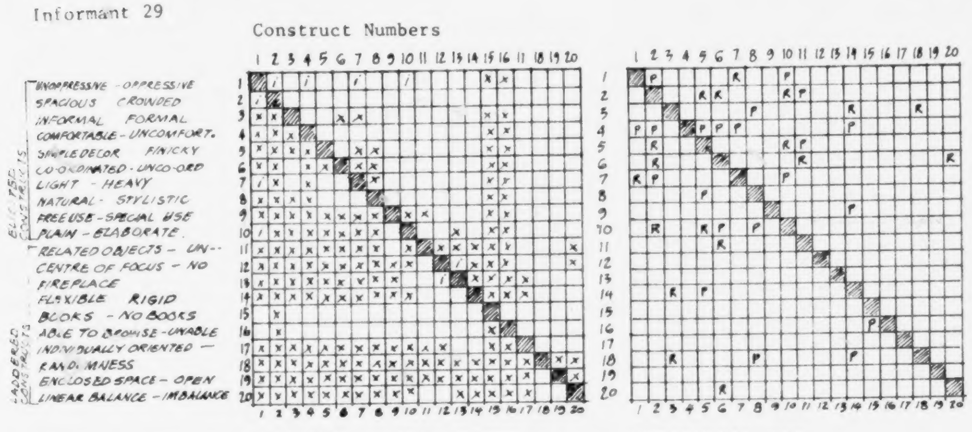
2. Laddering to Identify Subordinate and Superordinate Relationships: "Laddering" was the process used by Hinkle to identify constructs of increasing degrees of superordinacy in any construct network. In the case of the living room study it was decided that the laddering process would be used to find constructs of increasing degrees of subordinancy. In other if a trio of interiors resulted in the informant identifying a 'friendly-hostile' construct and the living room being studied was identified as being 'friendly' he was asked "what evidence do you have for saying it is 'friendly'? He would then give another construct, for example, 'cosy' then he would be asked"what evidence do you have for calling this room 'cosy'?" He would give another construct such as 'it has a low ceiling.' Eventually a series of three or four constructs would emerge, usually relating an abstract construct such as 'friendly' to a series of 'physical' or 'tangible' constructs such as the "relationship between two chairs," "the warm colours" or the "rough texture of the bricks." Most informants were able to identify 2 to 3 subordinate constructs relating to each of 5 or 6 superordinate constructs. Hinkle himself had much greater success in the number of superordinate constructs he was able to elicit within any given construct system. In reviewing his work Bannister and Mair express some surprise at the number of laddered stages he was able to elicit in any construct system. In his pilot study Hinkle found that his students could usually provide about 8 to 12 superordinate constructs.

   In British experiments, however, the total number of constructs elicited in any one system or "laddering" process was considerably less.

   Bannister also points out that Hinkle only presumed that all the constructs that he elicited using the first "Kelly Trio" method were subordinate. In the case of this environmental study it was found that in most cases these were superordinate and subordinate constructs were elicited from them. Before this second eliciting process began subjects were asked to nominate their polar preference in each of the ten construct pairs. In almost every case the informant did not consider that element 2 had qualities coinciding with all of their preferred poles in all of the ten constructs. The second eliciting process was only carried out with constructs where the pole applicable to the living room example was the same pole preferred by the informant. Usually 5 or 6 of the constructs were thus appropriate for the second eliciting process and each gave rise to two and in some cases three subordinate constructs. The "laddering" process was continued until the subject was no longer able to give further reasons for his previous construct, thus indicating that he had reached his stage of maximum subordinacy. Ten subordinate constructs were selected for use in the resistance to change and implication grids, which formed the fourth stage of the procedure.

3. Repertory Grid Test:
The next stage was to use the first ten (superordinate) constructs in the form of a repertory grid test. Ten of the living room picture examples were used as the elements, two of the pictures being the two most approved living rooms established in the first study. The subjects were asked to use a 7 point rating scale in scoring each element in terms of each of the constructs. The preferred poles of each construct were organised on the maximum side of the rating scale. The repertory grids were subjected to principal components analysis per kind favour of Patrick Slater under the auspices of his Medical Research Council grant.(Slater a & b).

4. Resistance to Change and Implication Grids: The informant, having completed the repertory grid test, carried out Hinkle's resistance to change and implication grids. Figure 1 shows examples of resistance to change and implication grids. The resistance to change grid is operated as follows. The ten superordinate constructs followed by ten subordinate constructs (derived from the laddering process) are listed down the left hand side of grid. The informant is then asked to consider construct No.1 with construct No.2 and to answer the following question "Regarding the particular living room being studied (Element 2) suppose you are being required to accept a polar change (i.e. a change from "good" to "bad" or "hot" to "cold") on one of these two constructs, which one would you prefer not to change?" An example of this could be that if the first construct was 'lived in/not lived in' and the second construct was 'friendly/unfriendly' the informant is asked to nominate whether he would prefer the particular living room being studied to remain 'lived in' and become 'unfriendly'


Informant 29
Construct Numbers
UNOPPRESSIVE - OPPRESSIVE
SPACIOUS CROWDED
INFORMAL FORMAL
COMFORTABLE - UNCOMFORT.
SIMPLE DECOR FINICKY
CO-ORDINATED - UNCO-ORD
LIGHT - HEAVY
NATURAL - STYLISTIC
FREE USE - SPECIAL USE
PLAIN - ELABORATE.
RELATED OBJECTS - UN--
CENTRE OF FOCUS - NO
FIREPLACE
FLEXIBLE RIGID
BOOKS - NO BOOKS
ABLE TO BROWSE - UNABLE
INDIVIDUALLY ORIENTED —
RANDOMNESS
ENCLOSED SPACE - OPEN
LINEAR BALANCE - IMBALANCE
ELICITED CONSTRUCTS
LADDERED CONSTRUCTS

RESISTANCE TO CHANGE GRID

Notes: An 'x' in a column indicates the informant was not prepared to change the construct identified by the column number. This means that the informant preferred to change the construct identified by the row number.
The letter 'i' indicates that a change in the column constructs automatically means a change in the row construct.

IMPLICATION GRID
'P' = Parallel implication
'R' = Reciprocal implication
A 'P' in a column indicates that a change in the construct identified by the column number implies a change in construct identified by the row number. An 'R' indicates that the constructs identified by both row and column numbers are reciprocally implicated.

Figure 1.

or whether it is more important to him that it should stay 'friendly' despite the fact that it would then become 'unlived in.' The informants made a decision in this way for each of the 20 constructs considered with each of the other 19 constructs. Clearly a construct with the highest resistance to change could be said to be the most highly ranked, important or superordinate construct. The application of this grid test resulted in the establishment of the hierarchical relationships of the informant's 20 constructs.

The implication grid works in a similar manner. The difference here is that informants are asked to imagine that 'suddenly' the room which they thought, for example, 'modern' becomes 'traditional.' Bearing this in mind they are then asked to consider each of the other 19 constructs to see if the change in the first construct necessarily and inevitably would create a change in the other 19 constructs. Once again each of the 20 constructs is considered in turn and the implication of a change in each of them is considered in terms of changes in each of the other 19 constructs.

To summarise, three grids are being applied in the study of this particular living room. The repertory grid uses the 10 superordinate elicited constructs and enables a comparative rating to be made on a graded rating scale for each of the 10 living room examples (figure 2 shows the scored repertory grids). The principal dimensions of construing the living rooms are thereby establishable by principal components analysis.

Having thus established the assessment of the room being studied and its relationship to other living rooms, the resistance to change and implication grids allow a study of the various construct networks which together build up the contexts in which approval or disapproval takes place.

We are also able to see which constructs fit into which context and the relative importance of each construct within each context and within the overall assessment network of 20 constructs. The role which any minor subordinate construct, be it a piece of furniture or texture in the room, plays in contributing towards the establishment of an overall abstract feeling, quality or characteristic of the environment is also evident and by a study of the implication grids one can see how changes even at a very subordinate level create changes both within the context and within other contexts. In this way the role of each construct can be to some extent monitored as it operates across and between the contexts and networks.

Illustration of Results

The results of the experiment had not been fully analysed at the time of writing this paper. Forty informants took part. Ten were architects and the others belonged to a "middle class," "middle income," "professional or equivalent" group.

The results of two informants, one architect and one non architect, are discussed. The determination of conclusions will depend on the final analysis and the following is only an example of the kind of information resulting from the experiment.

Figure 2 shows the scored repertory grids.

INFORMANT 29

ELEMENTS	1	2	3	4	5	6	7	8	9	10	
UNOPPRESSIVE	6	5	6	2	5	3	3	6	2	6	OPPRESSIVE
SPACIOUS	4	5	6	2	6	5	[illegible]	[illegible]	6	5	CROWDED
INFORMAL	5	6	5	3	4	[illegible]	2	3	2	4	FORMAL
COMFORTABLE	4	6	4	3	5	4	[illegible]	7	[illegible]	[illegible]	UNCOMFORTABLE
SIMPLE DECOR	3	6	5	3	6	3	5	4	3	6	FINICKY
CO-ORDINATED	2	6	4	5	5	6	4	[illegible]	5	7	UNCO-ORDINATED
LIGHT	6	3	6	5	[illegible]	[illegible]	4	7	6	6	HEAVY
NATURAL	4	6	[illegible]	3	4	1	5	4	[illegible]	5	STYLISTIC
FREE USE	6	5	[illegible]	2	6	5	3	5	[illegible]	4	SPECIFIC USE
PLAIN	3	6	4	3	5	3	5	3	1	4	ELABORATE

INFORMANT 36

ELEMENTS	1	2	3	4	5	6	7	8	9	10	
LIVED IN	7	7	7	4	4	7	1	4	7	1	UNLIVED IN
CONSISTENT	7	5	7	1	6	7	7	7	[illegible]	[illegible]	INCONSISTENT
SOCIAL	6	6	5	2	4	7	4	7	6	4	ANTI-SOCIAL
COMFORTABLE	6	4	4	6	4	6	1	5	1	6	UNCOMFORTABLE
WELCOMING	5	7	6	[illegible]	[illegible]	[illegible]	2	5	4	5	UNWELCOMING
SPACIOUS	6	4	7	7	6	6	2	7	7	7	ENCLOSED
UNCLUTTERED	4	4	7	5	6	3	2	7	1	5	CLUTTERED
WARM	5	6	2	4	2	6	6	4	2	5	COLD
AT EASE	5	6	4	5	3	[illegible]	2	6	2	5	UNSETTLED
FLEXIBLE	5	2	5	[illegible]	4	2	1	4	1	4	RIGID

Figure 2

Table 'A' indicates the relative ranking in terms of 10 personal constructs by the two informants.

Rank	Informant 29 (architect) Elements	Informant 36 (non architect) Elements
1st	2 & 5	1,8 & 6
2nd		
3rd	8	
4th	10	3
5th	3	2
6th	1	10
7th	6	4
8th	7	5
9th	9	9
10th	4	7

Table 'A'

The elements were compared with each other in terms of their ratings in order to see whether a difference in ranking indicated a large or small difference in assessment. This is done by mathematically plotting the co-ordinates of each element in a multidimensional space described in this case by the 10 dimensions used in the evaluation. If the distance between two elements in this space is large the elements will have been considered differently, conversely small distances indicate similarity.

Table 'B' indicates the 'similarity' of elements to element 2.

informant	small dists similarity	large dists dissimilar
29	1,3,5	9,6
36	1,6,3,8	7,4,9, 5, 10.

Table 'B'

Principal components analysis indicates the main superordinate zones of evaluation. The principal components may be considered the main contexts of the informant's construing of all the elements.

Principal components are so identified because they account for or include the largest Percentages of variance. (For the purpose of this discussion variance may be said to mean "range or spread of opinion"). The Slater analysis identifies the relationship or loading of each construct and each element to the various principal components.

Table 'C' shows the percentage of variance and 3 most highly loaded constructs and elements for each of the three principal components.

informant 29

principal component	% var	construct	element	rank
1	42.5	unoppressive	9	5
		comfortable	4	4
		informal	2n	7
2	21.8	free use	8	12
		plain	9	11
		light	7n	6
3	10.03	informal	1	7
		free use	3	12
		co-ordinated	8n	10

informant 36

	% var	construct	element	rank
1	40.32	comfortable	7n	10
		warm	9	9
		at ease	8n	1
2	27.37	lived in	6	1
		social	9	9
		consistent	2	5
3	12.17	consistent	4n	7
		social	10	6
		uncluttered	8	1

Table 'C'

Note: 1. Only the preferred pole of each construct is given.

2. 'n' = The element has a negative loading.

The constructs used for the laddering process were chosen for the following reasons.

1. Their approved poles related to Element 2.

2. They were positive, (not, for example, constructs like 'unoppressive') negative constructs tended to ladder down to further negative subordinates which indicated absences. These were seldom identifiable with the characteristics and features of Element 2.

Figure 4 shows the subordinate constructs derived by the laddering process for Informant 29 only.

The object of the work was to establish links (in the informant's construing process) between abstract evaluations (e.g. "lived in" or "informal") and physical characteristics (subordinate and sometimes other superordinate constructs e.g. "chairs round the fire" or "books"). The tables and figures provide information for making these links. There are 5 conditions under which links may occur,

1. A link by component loading.
   This applies to both elements and constructs, as indicated in figure

Element —— load factor → Component ← load factor —— Construct

2. A link by eliciting.
   An element is associated with a construct because it is considered similar to another element because of the construct.

3. A link by laddering.

4. A link by parallel implication.
   This indicates that the first mentioned construct is superordinate to the second. See pages 6-5-3/4.

5. A link by reciprocal implication.
   In this link the constructs are implicated with each other but either may be superordinate or subordinate.

Figure 3 is a schematic diagram of the 5 links.

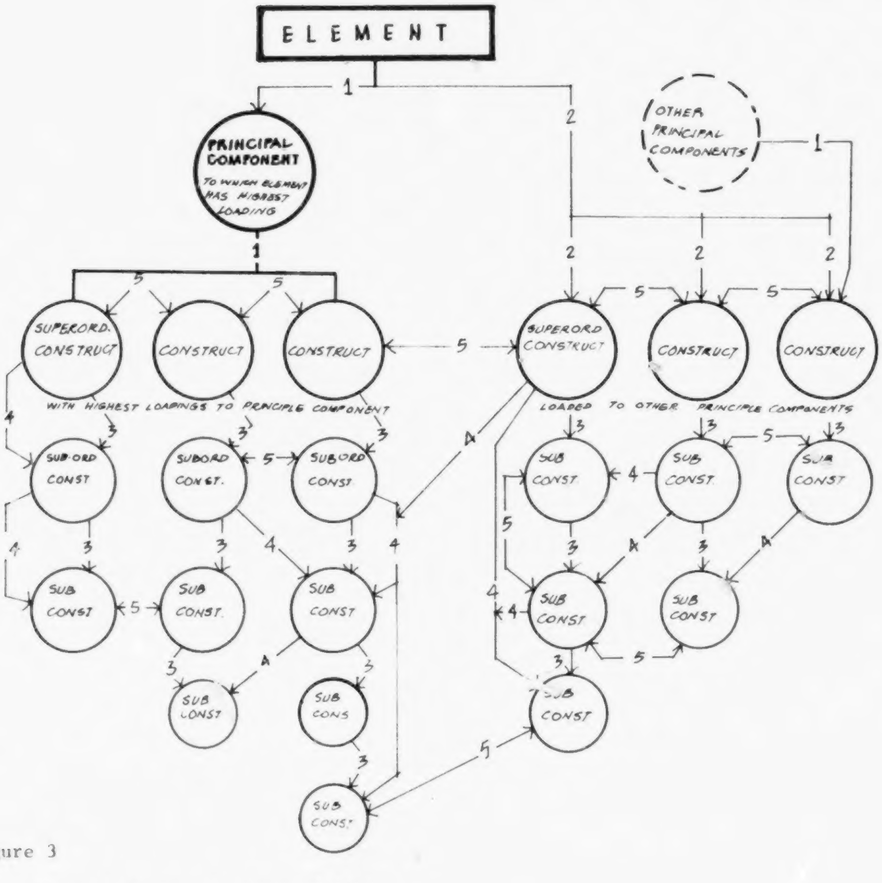

ELEMENT
1
2
PRINCIPAL COMPONENT
TO WHICH ELEMENT HAS HIGHEST LOADING
OTHER PRINCIPAL COMPONENTS
SUPERORD. CONSTRUCT
CONSTRUCT
CONSTRUCT
SUPERORD CONSTRUCT
CONSTRUCT
CONSTRUCT
WITH HIGHEST LOADINGS TO PRINCIPLE COMPONENT
LOADED TO OTHER PRINCIPLE COMPONENTS
SUBORD CONST
SUBORD CONST.
SUBORD CONST
SUB CONST
3
4
5

Figure 3

The numbers indicate the type of link

Figures 4 & 5 Show links between Element 2, Components and Constructs for Informant 29

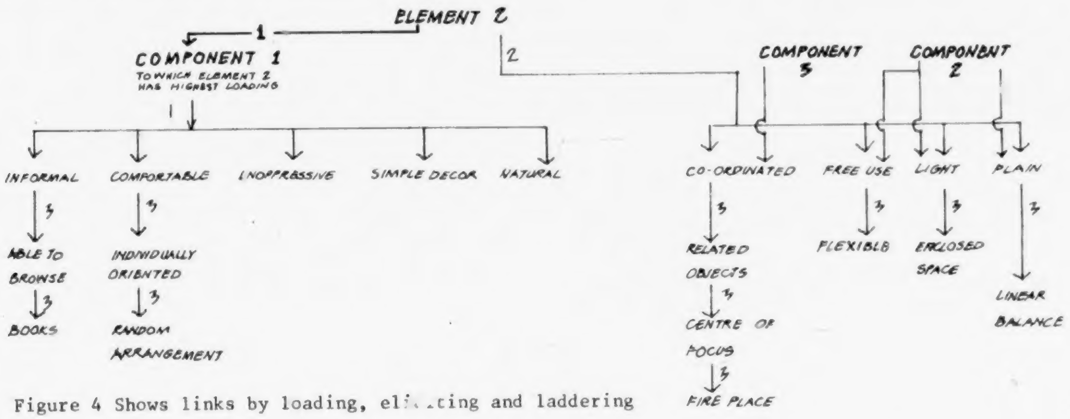

ELEMENT 2
1
2
COMPONENT 1
TO WHICH ELEMENT 2 HAS HIGHEST LOADING
COMPONENT 3
COMPONENT 2
INFORMAL
COMFORTABLE
UNOPPRESSIVE
SIMPLE DECOR
NATURAL
CO-ORDINATED
FREE USE
LIGHT
PLAIN
3
ABLE TO BROWSE
BOOKS
INDIVIDUALLY ORIENTED
RANDOM ARRANGEMENT
RELATED OBJECTS
CENTRE OF FOCUS
FIRE PLACE
FLEXIBLE
ENCLOSED SPACE
LINEAR BALANCE

Figure 4 Shows links by loading, eliciting and laddering

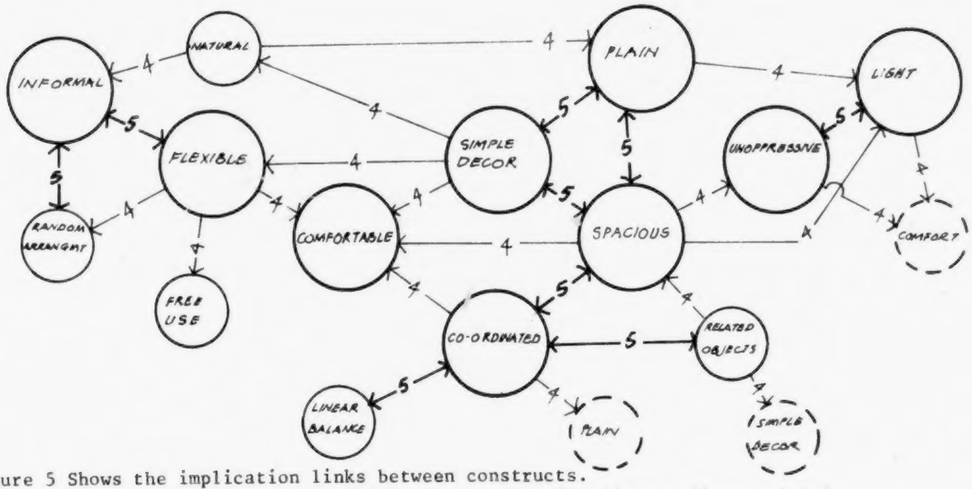

NATURAL
INFORMAL
PLAIN
LIGHT
FLEXIBLE
SIMPLE DECOR
UNOPPRESSIVE
RANDOM ARRANGMT
COMFORTABLE
SPACIOUS
COMFORT
FREE USE
CO-ORDINATED
RELATED OBJECTS
LINEAR BALANCE
PLAIN
SIMPLE DECOR
4
5

Figure 5 Shows the implication links between constructs.
Were it not for the complexity of the resulting diagram figures 4 & 5 would be combined so that traces of relationships between components, contexts and constructs could be made.

The numbers indicate the type of implication link. The dotted circles indicate that the construct is repeated for graphical clarity.

The overall object of the work is to study the relationship between "evaluation" and "environment". The establishment of links in construing enables patterns of relationships to be identified.

A relationship or network of relationships may be established by one or more links occurring because of one or more of the conditions.

Each of the 5 conditions establish links between the constructs of varying degrees of intensity. Deciding on the importance of links between constructs because of the types or combinations of the links is being undertaken and awaits the completed analysis of the results.

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A COMPARATIVE ANALYSIS OF AFFECTIVE RESPONSES TO REAL AND REPRESENTED ENVIRONMENTS

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There are many advantages in studying represented rather than real environments. The architect may represent his architecture by drawings, models, or slides of models, and measure people's responses to them before the buildings are actually constructed. It seems reasonable to assume that many architectural disasters could have been avoided if the reactions of their occupants or observers had been accurately measured beforehand. The researcher, in turn, may transform extraneous variables, such as the weather and the time of day, into constants by freezing reality on film. He may also study environments which are inconveniently located, and he may save time, trouble and money which must be spent to transport subjects to the environment of interest.

The disadvantage in using representations is that our subjects may not respond to them as they would to the actual environments. Although the pattern of behavior elicited by slides is interesting in its own right, it may tell us little about the subject's responses when confronted with the actual building, room, or landscape.

Given the advantages of using representations, it becomes increasingly important that we have objective data comparing responses to environments represented in various ways, so that both the architect and the researcher may make rational decisions about his method of stimulus presentation.

The research reported below is an attempt to collect some of this data. Out of the infinity of possible environments, we selected four buildings and six rooms within them. Undergraduates used a 28-item semantic differential to rate the actual buildings, color, and black-white slides. Although the affective responses to the real and represented environments were not the same, the differences are consistent enough for us to make several practical suggestions about the future use of slides as methods of representing environments.

Method

Subjects

The three groups of 59 subjects were volunteers from psychology courses as Colgate University. The first group evaluated the buildings themselves. It was composed of 44 males (mean age: 18.6 years) and 15 females (mean age: 18.1). The second group evaluated color slides of the buildings, and was composed of 46 males (mean age:18.6) and 13 females (mean age: 18.1). The third group evaluated black-white slides of the buildings, and was composed of 44 males (mean age:18.7) and 15 females (mean age:17.7).

The Environments

Each subject evaluated four buildings and six spaces within them. The buildings may be divided into two groups according to the subjects' familiarity with them and the use for which they were designed.

Familiar-Public: The Colgate University Library

The library was designed by R.B. O'Connor and W.H. Kilham and built in 1958. Each subject evaluated the outside of the building and the general study area. In order to provide an objective estimate of familiarity, 23 subjects from the black-white condition were asked to rate each building and room on a scale from 1 to 7, where 7 indicated maximum possible familiarity. The average familiarity rating for the outside of the library was 5.3 and the rating for the study area was 4.7.

Familiar-Public: The Colgate University Arts Center

The Art Center was designed by Paul Ruldolph and was built in 1964. Each subject rated the outside of the building (familiarity:5.0) and the central shaft (familiarity: 4.4).

Unfamiliar-Private: House 1 House 1 is a Victorian structure built in the latter part of the nineteenth century. The subjects rated the outside (familiarity:0.1) the living room (familiarity:0.0) and the attached dining room (familiarity: 0.0).

Unfamiliar-Private: House 2 This is a nondescript structure build about 1850. It is divided into two apartments. The subjects rated the outside of the house (familiarity:0.0), and the living room (familiarity:0.0) and dining room (familiarity:0.0) of the upstairs apartment.

The Semantic Differential

The subjects rated the environments with the semantic differential shown in Table 1. Although there has been some criticism of the semantic differential as a method for measuring the entire meaning of a concept (2) it has been a highly reliable and efficient method for rating the affective meaning of diverse concepts in many cultures (3,4).

We used two criteria to select the specific scales for the semantic differential. The first was their appropriateness for architected environments. Where ever possible we selected scales that had been used in previous studies of architecture (5,6). The second criterion was that approximately 1/3 of the scales load highly on Evaluative, 1/3 on Potency, and 1/3 on Activity factors as indicated by previous studies using the semantic differential (4). Most loadings were determined from data reported in Osgood, Suci, and Tannenbaum (4). The letter beside each pair in Table 1 indicates the factor on which it usually loads. Nine of the scales have their highest loadings on the evaluative factor, ten on the potency factor, and nine on the activity factor.

Design and Procedure

The Real Condition The 59 subjects were run in the afternoon between 2:00 and 5:00 on one of the days between November 16-21, 1970. Sixteen subjects were run on clear, sunny days, 43 were run on overcast days. The maximum temperature ranged between 45 and 60 degrees during the week of the experiment.

The subjects were divided randomly into groups of four, two subjects to each of two experimenters. The experimenters drove the subjects to the buildings in a specified order. Every attempt was made to counterbalance the order in which the buildings and room were rated so that progressive errors (e.g. fatigue) would be the same for each environment. For various reasons, we were not entirely successful. The serial orders of the ratings, however, do not differ significantly from each other.

All ratings of a given building or room were made from the same location, which was the location spontaneously used by pretest subjects and judged by them to be most suitable for their purposes. All ratings were done on seven-point scales and the order of the 28 scales was always the same. The poles of the scales were reversed for each subsequent rating. The instructions were the same in all important respects to those described by Osgood, Suci, and Tannenbaum (4).

Table 1. The Semantic Differential

Scale		Major Loading
heavy	light	P
excitable	calm	A
harmonious	dissonant	E
uniform	divergent	A
beautiful	ugly	E
large	small	P
stable	changeable	A
static	dynamic	A
strong	weak	P
passive	active	A
good	bad	E
formal	informal	A
light	dark	E
tense	relaxed	E
complex	simple	A
rational	intuitive	P
masculine	feminine	P
meaningful	meaningless	E
bold	unobtrusive	P
awkward	graceful	E
soft	hard	P
like	dislike	E
novel	common	P
stressful	tranquil	A
empty	full	P
constrained	free	P
intimate	distant	E
exhilarating	depressing	A

The Color Condition Two sets of slides were taken during the week of the experiment. One set was on the first sunny day of the real condition and the other set was taken on the second overcast day of the real condition. All slides were taken on 35mm. Ektachrome film, using a Nikormat camera with a 35mm. lens, from the exact location used by the subjects.

The subjects were run in groups of four over a three-week period during February and March, 1971. The slides were shown in a semidark room on a screen which was 5' 4" from the subject. The projected size of the image was 26" x 39".

The instructions and the design were essentially the same as those for the real condition. To provide comparable experiences, the subjects were shown a panorama of three to five slides which covered a range of about 150 degrees of visual angle. He always made his ratings from the slide which corresponded to the major view of the subjects in the real condition. Sixteen subjects viewed the slides taken on the sunny day, and the rest saw the dark slides.

The Black-White Condition The black-white slides were made directly from the color slides using Kodak Positive film and Acufine developer. Although the black-white slides were clear and sharp, observers generally agreed that their contrast was greater than the contrast in the color slides. To circumvent this problem, we measured the luminance of the projected image of each color slided and adjusted the average luminance levels for the black-white slides until they were equal.

The subjects were run over a three week period in October, 1971. The rest of the design and procedure were exactly the same as in the previous condition.

Results and Discussion

There are two general issues which we considered in detail in the following discussion. The first is whether the subjects in each condition used the semantic-differential scales in the same way conceptually. A detailed factor analysis of the data suggests that the answer is a qualified "Yes." A very powerful evaluative factor appears in the analyses for each building, but the second and third factors are less consistent.

The second issue is whether the subjects' ratings of the slides are the same as their ratings of the real environments. None of the three sets of ratings is exactly the same as the others, although there are fewer significant differences between the two slide conditions than between either slide condition and the real condition. Virtually all of the significant differences between slide and real conditions may be explained as either regression to the mean (i.e. less extreme ratings) or shifts toward the negative pole of the scale. The former trend is strongest for the familiar-public buildings and the latter is strongest for the unfamiliar-private buildings. These hypotheses successfully describe the differences between the two slide conditions for the familiar-public buildings, but they are only moderately successful for the unfamiliar-private ones. There is some evidence that regression and negation may be reversed by increasing the brightness of the slides.

Results from the Factor Analyses (7)

Table 2 shows the first three unrotated factors from four factor analyses performed over the four buildings. The most noticeable characteristic of this data is the tremendously powerful first factor which was extracted for all three conditions for all four buildings. The scales with the highest loadings on this factor are generally evaluative scales.

Table 3 contains Spearman rank-order correlation coefficients which were computed between each of the conditions within each of the buildings and across the 28 scales. They are all quite high for factor 1, with the exception of the coefficient between the black-white and color slide data from the Art center, which is only moderate. Thus there seems to be a powerful evaluative dimension which appears consistently across the four buildings.

The second and third factors are progressively less consistent. Table 3 shows that the average coefficients for these factors are quite low, suggesting that the subjects failed to use them in a consistent fashion. Factors 2 and 3 contain many scales which loaded highly on the activity and potency factors in previous experiments, but neither set dominates the other in any consistent fashion. (This is also true when the factors are rotated to find a more psychologically satisfying solution.) Thus it seems likely that subjects responded primarily to the evaluative dimension of the task, and failed to consistently differentiate between the activity and potency dimensions.

Results from the Analyses of Variance

There are two general questions which these analyses may be used to answer: Do the methods of representation affect the subjects' ratings? If so, what is the nature of the effect?

If the answer to the first question is "No," then, given an alpha level of .05, there should be no more than five significant analyses for each 100 analyses of variance computed on the data (8). We performed 280 one-way analyses of variance comparing the three presentation conditions on the 28 scales and ten environments. Of these, 50 were significant beyond the .05 level, which is significantly above the 14 we would expect to be significant by chance. We may conclude, therefore, that there are meaningful differences among the three presentation conditions.

Given that the answer to the first question is "Yes," we may answer the second by studying the pattern of significant t-tests between pairs of conditions within each triplet for which the analyses of variance was significant. A careful consideration of these results suggests two hypotheses which can explain most of the significant effects:

Table 2. Factor Loadings Over .40 on the First Three Unrotated Factors: a) The Library

Real Condition:	Load	Color Condition:	Load	Black&White Condition:	Load
Factor I					
like	.88	like	.87	like	.82
good	.88	exhilarating	.85	graceful	.82
exhilarating	.86	beautiful	.83	exhilarating	.79
intimate	.80	free	.75	soft	.75
meaningful	.72	graceful	.62	good	.73
graceful	.71	relaxed	.61	relaxed	.70
free	.70	meaningful	.55	intimate	.68
dynamic	.69	novel	.55	free	.65
novel	.68	full	.53	light(wt.)	.60
relaxed	.64	intimate	.52	tranquil	.58
soft	.62	harmonious	.51	meaningful	.57
tranquil	.59	light	.47	harmonious	.55
bold	.54	soft	.44	dynamic	.51
full	.53	tranquil	.44	informal	.46
harmonious	.49			intuitive	.44
strong	.47			novel	.43
active	.44			active	.42
changeable	.44				
light(wt.)	.42				
Factor II					
uniform	.68	simple	.64	common	.69
harmonious	.67	tranquil	.64	unobtrusive	.68
formal	.60	informal	.60	weak	.63
simple	.53	feminine	.54	simple	.50
heavy	.48	unobtrusive	.52	tranquil	.50
rational	.44	static	.43	relaxed	.50
tranquil	.40	relaxed	.40	static	.42
graceful	.40			feminine	.42
				informal	.40
Factor III					
feminine	.76	excitable	.66	stable	.73
weak	.60	weak	.62	excitable	.65
soft	.50	active	.51	rational	.54
unobtrusive	.48	changeable	.51	light	.52
light	.41	small	.45	harmonious	.45
light(wt.)	.41			passive	.44
				masculine	.43
				large	.41
				static	.41

Table 2. Factor Loadings Over .40 on the First Three Unrotated Factors: b) The Arts Center

Real Condition:	Load	Color Condition:	Load	Black&White Condition:	Load
Factor I					
exhilarating	.80	exhilarating	.79	exhilarating	.86
good	.80	good	.79	good	.85
like	.76	beautiful	.79	like	.80
active	.69	strong	.78	beautiful	.79
free	.69	like	.76	free	.75
beautiful	.66	novel	.68	graceful	.74
meaningful	.64	large	.59	intimate	.73
dynamic	.62	meaningful	.58	harmonious	.68
excitable	.58	masculine	.55	meaningful	.66
strong	.57	light	.49	relaxed	.60
novel	.55	bold	.46	tranquil	.54
large	.54	complex	.43	active	.55
light	.45			light	.51
bold	.45			novel	.50
graceful	.44			stable	.45
intimate	.43			full	.44
Factor II					
relaxed	.62	stable	.73	small	.64
feminine	.60	harmonious	.71	light	.62
free	.58	passive	.69	relaxed	.57
tranquil	.58	tranquil	.66	simple	.56
informal	.56	relaxed	.61	feminine	.51
light(wt.)	.56	simple	.59	unobtrusive	.51
weak	.47	intimate	.57	weak	.49
unobtrusive	.45	calm	.56	calm	.49
small	.42	soft	.52	divergent	.46
		unobtrusive	.47	intuitive	.45
		graceful	.46	informal	.45
				tranquil	.44
				common	.41
				free	.41
Factor III					
harmonious	.78	dynamic	.65	static	.68
uniform	.62	full	.63	soft	.65
soft	.58	free	.61	passive	.65
intimate	.58	informal	.60	stable	.47
static	.51	graceful	.54	formal	.43
tranquil	.45	intuitive	.51	unobtrusive	.43
beautiful	.43	active	.51		
passive	.41	divergent	.48		
relaxed	.41	relaxed	.47		

Table 2. Factor Loadings Over .40 on the First Three Unrotated Factors: c) House 1

Real Condition:	Load	Color Condition:	Load	Black&White Condition:	Load
Factor I					
like	.85	like	.84	beautiful	.87
good	.78	beautiful	.83	like	.87
exhilarating	.78	exhilarating	.82	good	.83
intimate	.77	good	.79	intimate	.82
beautiful	.68	full	.76	free	.79
light	.68	graceful	.74	full	.75
dynamic	.68	meaningful	.71	exhilarating	.74
free	.68	novel	.66	dynamic	.70
graceful	.62	bold	.62	soft	.70
active	.60	soft	.59	meaningful	.68
soft	.54	intimate	.57	novel	.61
meaningful	.49	active	.46	changeable	.61
full	.49	harmonious	.45	graceful	.60
changeable	.48	strong	.46	active	.56
simple	.42	light	.43	complex	.49
		free	.41	feminine	.47
Factor II					
tranquil	.81	tranquil	.81	tranquil	.67
calm	.74	stable	.73	informal	.65
unobtrusive	.70	static	.64	unobtrusive	.64
simple	.69	calm	.68	small	.60
harmonious	.67	harmonious	.63	relaxed	.59
relaxed	.66	passive	.55	weak	.58
uniform	.53	rational	.45	calm	.56
common	.51	masculine	.42	simple	.50
passive	.47	simple	.40	passive	.47
static	.43			feminine	.46
small	.42			light	.46
Factor III					
formal	.75	heavy	.65	light	.61
strong	.59	formal	.63	harmonious	.60
large	.55	complex	.51	rational	.51
harmonious	.48	tense	.47		
stable	.47	constrained	.46		
uniform	.46	rational	.46		
beautiful	.44				
rational	.44				

Table 2. Factor Loadings Over .40 on the First Three Unrotated Factors: d) House 2

Real Condition:	Load	Color Condition:	Load	Black&White Condition:	Load
Factor I					
like	.88	like	.85	like	.22
exhilarating	.80	beautiful	.85	soft	.75
beautiful	.79	good	.75	exhilarating	.74
good	.78	graceful	.74	graceful	.71
active	.66	exhilarating	.71	beautiful	.70
intimate	.63	intimate	.68	intimate	.70
dynamic	.60	free	.67	dynamic	.70
graceful	.60	meaningful	.63	relaxed	.69
full	.59	harmonious	.60	free	.66
meaningful	.55	full	.58	active	.64
free	.54	relaxed	.55	light	.61
harmonious	.51	novel	.45	meaningful	.56
changeable	.51	soft	.43	good	.55
relaxed	.49	dynamic	.41	novel	.54
light	.48			intuitive	.54
intuitive	.47			informal	.49
strong	.47			feminine	.48
				light(wt.)	.47
				tranquil	.46
				changeable	.43
Factor II					
simple	.76	simple	.76	simple	.76
unobtrusive	.72	tranquil	.71	tranquil	.66
tranquil	.68	unobtrusive	.70	common	.64
relaxed	.66	calm	.66	unobtrusive	.64
calm	.61	common	.63	small	.54
soft	.60	stable	.60	calm	.53
light(wt.)	.58	harmonious	.55	static	.44
informal	.52	passive	.55	relaxed	.41
novel	.49	light	.52	empty	.40
intimate	.45	relaxed	.50		
free	.40	static	.43		
Factor III					
graceful	.57	feminine	.69	weak	.69
uniform	.56	weak	.55	dissonant	.55
constrained	.54	soft	.51	changeable	.53
formal	.51	small	.51	light(wt.)	.49
harmonious	.48	intuitive	.42	small	.46
meaningful	.47				
feminine	.46				
stable	.45				

Hypothesis 1: To the extent that the representation of the environment deviates from the actual environment, the subjects' ratings tend to regress toward the mean of the scale and/or to move toward its negative pole.

Hypothesis 2: Regression toward the mean is strongest for the familiar-public buildings and the shift toward the negative pole of the scale is strongest for the unfamiliar-private buildings.

In order to test these hypotheses, we first assumed that color slides deviated less from the actual environments than did black-white slides. Second, we assumed that the positive pole of each scale was the one which was aligned with the "good" and "like" poles extracted by the factor analyses shown in Table 2. Given these assumptions, it is possible to compute the frequencies of significant differences explained by regression and negation for each of the ten environments.

Table 4 shows the results of this analysis. Hypothesis 1 explains 100% of all significant effects on the ratings of familiar-public environments. It explains 95% of all significant effects on the ratings of unfamiliar-private environments. Thus there is good reason to assume that Hypothesis 1 is correct. Further, 92% of the entries for the familiar-public environments are explained by regression and 77% by negation, whereas 60% of the entries for the unfamiliar-private environments are explained by regression and 87% are explained by negation. This supports the second hypothesis.

There are also two minor hypotheses suggested by the data. The first is that affective responses to the black-white slides are not much different from responses to color slides. This is particularily true for the unfamiliar-private environments, where there were only 20% as many significant differences between the two slide conditions as there were for the other two comparisons. This hypothesis is also supported by Hershberger's (6) study in which he found very similar patterns of responses to color and black-white slides of familiar-public buildings.

The second minor hypothesis is that regression and negation may be reversed by increasing the average brightness of the slides. There are only two significant analyses of variances for the living room of the second house. This differs remarkably from the 15 significant differences for the outside of the same house, and from most of the other environments. In searching for an explanation, we noticed that one of the two significant differences for the living room was on the light-dark scale; the slides were judged to be much brighter than the actual room. In contrast, the outside of the house was judged to be significantly darker in the slides. Some informal pretesting suggests that the subjects' brightness ratings are directly related to the brightness of the slides. The same hypothesis might also help to explain the similarities between the two slide conditions which were balanced for brightness. In future research, it may be possible to overcome the differences between responses to real and represented environments by artificially increasing the brightness of the slides.

Table 3. Rank-Order Correlation Coefficients
Between Factor Loadings

		Library		Art Center		House 1		House 2	
Factor		Co	BW	Co	BW	Co	BW	Co	BW
1	Rl:	.82	.80	.61	.61	.67	.69	.79	.66
	Co:		.76		.34		.59		.67
Factor 2	Rl:	.19	-.14	.12	.70	.47	.46	.54	.48
	Co:		.61		-.11		.29		.57
Factor 3	Rl:	.37	.13	.13	.43	.22	.35	.30	.23
	Co:		-.16		.08		.36		.16

Rl=real condition, Co=color condition,
BW=black-white condition

Conclusions

There are two sets of conclusions from this experiment, one for the the researcher interesed in using slides to study environments, the other for the methodologist interested in developing methods for representing environments.

It is always dangerous to generalize from a small amount of data. Certainly the results of this experiment must be considered directly applicable only to the populations of subjects, buildings, and scales described above. At the same time, suspending judgment is a disservice to those who must use slides for whatever reasons. Thus, with considerable trepidation, we would like to make some tentative but practical suggestions:

1. Use the actual environments if possible. Our subjects' affective responses to slides were not the same as other subjects' responses to the actual environments. There may be ways to improve the representations, but slides which simply record the subjects' view do not elicit exactly the same patterns of affective responses as the actual buildings and rooms.

2. If you use slides, and viewers like your building or room, there is a good chance that they will love it when they actually see it. Our slides elicited less extreme responses from our subjects (regression toward the mean) and more negative feelings than did the

Table 4. Fractions and Percentages of Significant Differences Between Presentation Conditions Explained by Regression Toward the Mean (Reg), Movement Toward the Negative Pole of the Scale (Neg), and Both Combined (R+N)

	Real Environments Vs. Color Slides			Real Environments Vs. Black-White Slides			Color Slides Vs. Black-White Slides		
	Reg	Neg	R+N	Reg	Neg	R+N	Reg	Neg	R+N
Library	*								
Outside:	4/4	1/4	4/4	3/4	2/4	4/4	0/1	1/1	1/1
Inside:	3/3	3/3	3/3	3/3	3/3	3/3	0/0	0/0	0/0
Arts Center									
Outside:	3/3	1/3	3/3	5/6	4/6	6/6	3/3	3/3	3/3
Inside:	5/5	4/5	5/5	10/11	10/11	11/11	5/5	5/5	5/5
Sum	15/15	9/15	15/15	21/24	19/24	24/24	8/9	9/9	9/9
Percent	100	60	100	88	79	100	89	100	100
House 1									
Outside:	9/13	13/13	13/13	10/14	14/14	14/14	0/2	1/2	1/2
Living Rm:	1/2	1/2	1/2	2/2	1/2	2/2	2/2	2/2	2/2
Dining Rm:	6/7	5/7	7/7	5/7	5/7	6/7	1/1	1/1	1/1
House 2									
Outside:	1/5	5/5	5/5	3/7	5/7	6/7	2/3	1/3	2/3
Living Rm:	7/10	9/10	10/10	6/10	9/10	10/10	0/2	1/2	1/2
Dining Rm:	5/11	11/11	11/11	6/11	11/11	11/11	0/0	0/0	0/0
Sum	29/48	44/48	47/48	32/51	45/51	49/51	5/10	6/10	7/10
Percent	60	92	98	63	88	96	50	60	70

* The derominators of the fractions represent the total number of significant t-tests, given that the analysis of variance across the three presentation conditions was significant. The numerators represent the number of t-tests explained by regression, negation, or both as indicated above the column.

actual environments.

3. Subjects may tend to be more neutral (i.e. their judgments will regress to the mean of the scale), rather than negative if you show them slides of familiar-public buildings. They will react more negatively if you show them unfamiliar-private ones.

4. If you use slides, it makes very little difference whether they are in color or black and white. Color slides produced slightly less distortion, but the difference was slight and not always in favor of the color slides.

5. If you use slides, make sure they are bright and sunny. Our data suggest that it can't hurt and it may prevent regression and negation.

6. Pick your subject population carefully. Our Eastern-College, Liberal-Arts undergraduate tended to think first about whether he liked our buildings. He was much less consistent in his use of other dimensions of affective meaning. In this respect he may differ substantially from the architectural and prearchitectural students used by Hershberger(6) . His subjects responded consistently on other dimensions besides evaluation. In short, don't use our population of subjects unless you are interested in our population of subjects.

The results of this experiment also point clearly to the need for further research comparing represented and real environments. The advantages of representing environments are considerable if we can be sure that our conclusions generalize to the real environment. There are two ways we may approach the problem. The first is to improve the representation until it elicits the same responses as the real environment. The second is to describe the ways in which responses to a given representation will deviate from responses to the real environment. We have made suggestions above toward both of these goals, but much more effort is needed in all areas of environmental representation.

Notes

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Hershberger, R.G. A study of meaning in architecture. *edra 1. Proceedings of the 1st annual Environmental Design Research Association Conference, 1970* (H. Sanoff and Sidney Cohn, Eds).

(7) Ten factor analyses were computed over the ten buildings and rooms using the principal factor method and a minimum eigenvalue of 1.0. This procedure yielded six to nine orthogonal factors for each location and condition which we then subjected to a Varimax rotation. From the means, standard deviations, and factor loadings, it seemed likely that the conceptual dimensions which the subjects were using to rate the inside and outside of any given building were approximately the same. In order to further stabilize the data, each subject's responses to the inside and outside of each building were colapsed and a new set of four factor analyses performed, one for each of the four buildings. The unrotated factor matrices revealed an extremely powerful primary factor and only one or two minor factors with any meaning. When even three factors were rotated, the primary factor was fractionated and its components divided among the three, making it difficult to interpret them in any meaningful way. For this reason, the major analyses were performed on the first three unrotated factors which are shown in Table 2.

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THE DIMENSIONS OF THE VISUAL ENVIRONMENT: METHODOLOGICAL CONSIDERATIONS[1]

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Abstract

An approach to characterizing complex environments is proposed that grows out of the view of research as a continuing process rather than a discrete event. Rather than emphasizing prediction as the sole aim of research, this approach places an equal emphasis on understanding and on the refinement of measurement as well. In order to maximize these goals, a four-step feedback loop is proposed:

(1) A sampling process, often aided by a panel of judges, for insuring that the situations or stimuli in question are suitably representative;

(2) Ratings of the stimuli by subjects on the basis of preference, and perhaps on other attributes as well, if the latter are chosen with certain constraints in mind;

(3) Dimensional analyses to obtain the underlying structure or natural grouping of stimuli, thus simplifying the characterization of the environment in question;

(4) The interpretation phase calls on the skill and imagination of the investigator. He must figure out what the obtained groupings of stimuli mean and what is missing that resulted in certain stimuli failing to group. The groupings provide a basis for further analyses within the study as well as for measurement in subsequent research. The failures to obtain groupings stimulate alternative hypotheses and a search for the missing stimuli to be used in future studies.

Examples of various ongoing research are briefly described to illustrate the diverse applicability of the proposed approach.

A compact, reliable means of characterizing the visual environment would be of considerable interest. For management and design purposes it is useful to have well-defined categories representing key features of different environmental regions. For aesthetic purposes it is tantalizing. A number of investigators have recently worked in this area, including Coughlin and his colleagues (1970; 1971), Jacobs and Way (1969), Litton (1968), Shafer, Hamilton and Schmidt (1969), and several others mentioned in Craik's (1971) excellent paper. This growing literature on the evaluation of landscape aesthetics and landscape quality is both stimulating and frustrating. Stimulating because of the fascinating possibilities and suggestions raised; frustrating because of the methodology that is uneven and frequently inadequate. The purpose of this paper is to propose a methodology that is systematic, yet flexible. It is equally applicable to a large range of settings, including landscapes, architectural interiors, or studies of specific components of the environment; likewise, it can be used equally well with a wide range of stimulus material, including photographs, actual settings, and verbal descriptions.

The methodology described here is not merely a set of procedures but rather an expression of an attitude and approach to doing science. It is a process-oriented approach which recognizes that, in general, a single study does not prove or disprove anything, and that one of the most important outcomes of a well-designed experiment is guidance as to how to come closer to one's objectives the next time around. In that sense, the research in any area that is not yet thoroughly studied is necessarily exploratory.

Measurement is at the heart of any scientific study and ideally the measuring procedures or instruments become improved and refined in successive studies. It may seem to some that measurement is a rather straightforward process of obtaining objective readings on the real world. But such "raw" data is alas a fiction. In his exciting book, The structure of scientific revolution, Kuhn (1962) makes clear that there is no raw data, but rather data are collected in terms of what one has in mind and thinks is interesting -- in other words, in terms of some sort of theory. This conclusion returns to measurement the heavy responsibility of being reasonable and appropriate, and it makes it all the more likely that successive studies will be needed. Such a bootstraps procedure follows in the construct validation tradition first proposed by Cronbach and Meehl (1955), and is in keeping with the converging operations notion proposed by Garner, Hake, and Eriksen (1956).

In the description of the steps involved in the proposed approach to studying the dimensions of the visual environment, it will be evident that such considerations are of central importance. These steps involve a feedback loop in that the outcome of the fourth step is in general a better basis for starting with step one the next time around.

1. The selection of items (or slides, or settings, or etc.)

The crucial issue in selecting appropriate material is adequate sampling of the domain of interest. As Brunswik (1956) often emphasized, the sampling of subjects is routine; sampling of situations is usually ignored. A single slide, for example, has all sorts of specific aspects to which a subject might be responding. Only by providing a range of material having essentially the same content can the reaction of the subjects be interpreted. At the same time, the instances must not be virtually identical.

There is definitely a problem here in deciding on which instances to include for each content category under study. The experimenter may be tempted to shoulder this burden using his considerable intuition and expertise in the area. However, the decision basis is often on solider footing if a panel of judges is used to help in this process. By starting with considerably more instances than one eventually plans to use and obtaining the ratings of several judges as to the content category each instance falls in, a balanced collection of material can be selected.

The job of the panel of judges is relatively straight forward. Agreement on aesthetic evaluation, for example, is quite high (Craik, 1971). While judges may be quite reliable in their estimates of even as global a concept as "artistic merit," their agreement will be greater with a well-defined and explicit task. One might, for example, have the judges rate a series of scenes for the amount of mystery or intrigue, or for how easy it is to figure out what the picture represents. Because their job is relatively unambiguous, it is neither necessary to use a large number of judges, nor, in many cases, that they have special qualifications.

2. Subject ratings

While the judges were concerned with ratings of content, there are good arguments for asking the subjects to rate on the basis of preference. It is, after all, people's preferences that are often of primary practical and theoretical interest. Certainly other sorts of ratings are also appropriate, but with two constraints. First, it is important not to ask the subjects to make too many ratings on a single item, lest there be a tendency to rate the item high or low on all the scales -- the "halo effect" problem. Second, certain ratings may bias other ratings and should thus be avoided. Thus, for example, if the subjects are asked to indicate both how much litter is visible in the scene and how much they like it, one can expect results different from those obtained with the same pictures where only preference ratings are obtained. This kind of biasing is also a problem if one presents the items several times, each time with the job of obtaining a different rating. If the study necessarily involves too many different features to be rated, it is preferable to limit the job of any one group of subjects to two or three scales. Different groups might each have one of the ratings in common to enable comparisons across the groups.

There is always the problem of deciding on a suitable scale. A scale with any number of points, from 2 to 10, or even without specified points, can be supported by precedent. The meaning of each point on the scale can be identified precisely, or the meaning of the scale's endpoints can be indicated, and again there is precedent. There is no single right answer to these issues. There is also the question of whether an odd-number or even-number of alternatives is preferable. The argument is that with an odd-number of choices the subject can place himself noncommittally in the center. We have generally found 5-point and 6-point scales for subject ratings to be satisfactory across a great variety of different attributes.

A few words should be said about binary alternatives. The choice of only two alternatives tends to be frustrating to the subject. Humans seem to want room to express their judgment beyond a definite yes or no. In addition, binary alternatives can accentuate problems of response bias and response style. Low item variability strongly affects subsequent analyses. As Nunnally (1967) points out, "Usually fewer multipoint items than dichotomous items are required to obtain a particular reliability" (p. 259).

3. Use of an analytic procedure

The goal of the proposed approach is not merely to be able to predict settings that people will like or even that certain identifiable groups of people will like. The primary goal is to obtain meaningful dimensions, to find sensible, interpretable groupings of items that will extend our understanding at least as much as our predictive power. Traditionally, correlational techniques are used in analyzing such data, and some of these are peculiarly ill suited to speaking to our intuition or enriching our understanding. Multiple regression equations are a frequently employed instance of this difficulty. With such an exceedingly precise statement of the obtained results, one learns that X times this item (say, density of the foreground elements), plus Y times this item (say, the number of clearly identifiable components), plus Z times yet another item (degree of man-madeness) -- this accounts for about half or three-quarters of the variance. Even the authors reporting such equations have acknowledged the difficulty of interpreting such findings.

Direct inspection of intercorrelations among variables also has its drawbacks. For one thing, such a procedure becomes unwieldy with more than a handful of variables. Further, two items can be meaningfully related without necessarily having a high correlation with each other. If the two items have similar patterns of relationships with all other items, their comparable behavior qualifies them for membership in the same grouping. Finding such meaningful groupings is the domain of a series of computational techniques called dimensional analysis. Factor analysis is but one of the techniques that fit this description, albeit the best known one. It has been the object of considerable distrust, some of it justified. Traditional factor analysis depends, among other things, on the magnitudes of the correlations obtained, and these will vary from sample to sample even when the relative ordering of the correlations remains essentially constant.

A form of dimensional analysis that is free of this problem is the non-metric factor analysis, or monotone vector analysis, in the Guttman-Lingoes Smallest Space Analysis series (SSA-III) (Lingoes, 1966, 1967). The procedure here involves a rank-ordering of the original correlation matrix and the dimensions are then found using this transposed matrix. This procedure yields precisely the sort of dimensions required for enhancing one's understanding and improving one's measures.

Dimensional analyses also include other methods based on distinctly different algorithms. While in factor analytic methods (including the Lingoes SSA-III) all variables and dimensions are initially found simultaneously, other approaches use a more sequential strategy, a procedure that is intuitively easier to grasp. In the various methods based on Tryon's original work in this area (cf. Tryon & Bailey, 1970), the initial step involves finding a "pivot" variable (e.g., the variable that has the highest relationship to the largest number of other variables in the set) and forming a cluster with it by finding the other variables that have similar patterns of relationships.

The particular form of a Tryon-related dimensional analysis we have used represents a compromise between the sequential method just described and the approach which extracts factors simultaneously. ICLUST, developed by Kulik, Revelle and Kulik (1970), is a "hierarchical cluster analysis" that is fast and efficient and presents the resulting dimensions in a way that permits an easy understanding of the spatial relationship among the variables.

We have found that using the SSA-III and ICLUST procedures on the same set of data leads to a fuller understanding of the results. It also avoids the easily attained comfort of fully believing the truth of the output of any one computational procedure. Any statistical procedure is influenced by its own assumptions and decision rules. Each of them achieves its simplification on the basis of throwing away somewhat different information.

There is an intimate relationship between the extensive environmental sampling proposed in step one and the analytic procedures of step three. On the one hand, extensive sampling is essential if there is to be an adequate basis for forming dimensions. On the other hand, the willingness of the scientist to deal with large numbers of variables is based in large part on the simplification inherent in the dimensional analysis. In this framework, one need not settle on a few critical variables at the outset in order to insure that one will end up with something manageable.

4. Interpretation and stragegy for research

The proposed methodology is not automatic and mechanical in the sense that the results require no thought or interpretation. On the contrary, the results are in a form that encourages and enhances the use of theory and intuition, and the drawing of implications for future studies requires disciplined imagination of this kind. Certain obtained dimensions or clusters (i.e., groupings of items or slides or whatever) will have fairly apparent interpretations. In some cases, discrepancies between two methods of deriving dimensions will lead to interesting questions. In still other instances, the resulting dimensions will suggest a tentative possibility, or perhaps several alternative possibilities. In such events the obvious strategy involves the addition of items to the stimulus material that further explore these interpretations. If the hunch was correct, these new items will load on (become members of) the dimensions in question. Likewise, when there are too few items of a given kind to form a meaningful dimension, the possibility of additional items should be explored. If picked properly these should then lead to the formation of the appropriate dimension. In other words, additional material can be used to test hypotheses about the bases for both obtained dimensions and apparently missing dimensions. Of course the addition of new material returns us to the first step, that of adequate sampling of a domain. It is the discovery of such suggestive results that points precisely to domains not yet adequately sampled.

Another function of a dimensional solution is the identification of a coherent set of items that can then be treated as a unit. Thus, rather than considering individual scenes or settings, a composite score can be computed consisting of the sum of the ratings for the pertinent instances. Having such composite scores one is then in the position of comparing them with each other and studying them as a function of any available background information.

The initial step in this process was the selection, with the help of judges, of a set of material that samples the content categories of interest to the investigator. The subjects then rated this material along dimensions of concern to the investigator. The results of dimensional analysis provide a check and an enrichment of the domains the investigator set out to study. Their purpose is not so much to tell the investigator what the subjects like most, or where they would most like to spend their time. (The subject ratings can be averaged and compared to answer questions of this kind.) The dimensions reveal the structural relationships among the variables, the groupings of items that bear strong similarities.

Some examples

Without going into great detail, it might be helpful to mention some of the diverse kinds of studies we and our students and colleagues are now undertaking that are amenable to this form of analysis. The study described by Kaplan and Wendt (1971) is an excellent example. Slides depicting various scenes which judges rated on a four-category man-made to nature continuum were rated by subjects for complexity, excitement, and preference. The resulting dimensions for all three rating scales showed strong nature and urban dimensions. The nature dimensions included scenes with definite man-influenced components. The dimensions including suburban scenes were not as meaningful, pointing clearly to the need to better sample this domain. While the purpose of the study was not the determination of these dimensions, the dimensional analyses permitted a categorization scheme based on subjects' ratings rather than on the investigator's a priori notions.

A study of the reaction people have to landscape graphics as opposed to landscape photographs also uses this technique. If the presentation medium is unimportant, the dimensions will fail to reflect the distinction. If, on the other hand, it does make a difference, the differences in what graphics communicate and what photographs communicate may be clarified. Very likely there will be an indication of the different imp[illegible] of different modes of graphic presentation.

Several other studies, while not explicitly using judges to aid in the stimulus selection process, otherwise follow both the procedures and the spirit of the proposed approach. Two of these are concerned with "cognitive maps" and directly expose the subject to a wide range of environmental stimuli. A study involving subjects' cognitive maps of the central campus region permits us to determine the basis for grouping of certain features. Are these maps a function of the subjects' relative uses of the various buildings, of their architectural features, of their position along the main paths, etc.

Our research with cognitive mapping of the natural environment will help define what the salient features in such a setting may be. The kinds of features that Lynch (1960) found may not be as pertinent in the natural environment.

Some citizens in a nearby community participated in a study involving the visual and physical characteristics of their village, with the intention of helping maintain and enhance those features that were important to the community. By performing separate dimensional analyses of the responses by the men and women, we found that their views of their town are strikingly different. It will furthermore be useful to identify the important characteristics for the old-timers and the relative newcomers. And discussion of their goals should be more tangible as a result.

It should be emphasized that in all these studies the use of dimensional analyses is not the end point. Identifying dimensions really starts the process of making sense out of the study. Once one knows what the basic dimensions are and what they might be about, one has a whole new set of questions about their interpretation and their interrelationships. The reduction from wide situation sampling to a few composite scores permits great simplification of the domain being studied. The questions that arise in this fashion tend to be better focussed and more manageable than the questions that led one into that research domain in the first place.

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Note

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PREFERENCE AND THE VISUAL ENVIRONMENT: COMPLEXITY AND SOME ALTERNATIVES[1]

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Abstract

In order to test the hypothesis that environmental preference, including the preference for nature scenes, can be accounted for in terms of the complexity of the stimulus array, 88 subjects were asked to rate 56 color slides both for preference and for complexity.

Dimensional analyses were carried out to identify coherent groupings of slides. One group of slides consistently loading on a nature dimension and one group consistently loading on an urban dimension were selected for further analysis. Three major results were obtained:

(1) Nature scenes were greatly preferred to urban scenes ($p < .001$)

(2) Complexity predicted preference within the nature domain ($r=.69$) and within the urban domain ($r=.78$)

(3) Complexity does not account for the preference for nature over urban slides; the greatly preferred nature slides were in fact judged on the average less complex than the urban slides.

Following an informational approach, a tentative theoretical framework is proposed that makes complexity a component, along with mystery, of a "predicted information" dimension. Another dimension seen as underlying a subject's preference for a given environmental setting is that of legibility, consisting of identifiability and coherence. A category of "primary landscape factors" including water, paths, and nature in general is proposed as the third major determinant of preference in the visual environment.

Anecdotal evidence that people like nature, that they even have a preference for graphics and photographic representations of nature, abounds. Understanding this preference may be an important step in the large and vital task of understanding the kinds of environments necessary for man's psychological well-being. It may be that this preference for nature (assuming it can be demonstrated) is just what it appears to be, that is, a special reaction to nature per se. Iltis, Loucks, and Andrews (1970), among others, have argued that a profound underlying preference of this kind is related to man's evolution in natural settings over a period of millions of years. On the other hand, it may be that the preference for nature is simply an expression of some other, more basic psychological component. For example, Wohlwill (1970) has suggested that human reactions to slides of the environment, both natural and man-made, are based on the underlying complexity of the visual array.

Complexity has been an important factor in human preference for stimulus patterns, and the application of this same variable to environmental configurations would be, as Wohlwill suggests, a substantial scientific achievement. At the same time the implications of such a finding should be clearly understood. If man's preference for nature is merely an outcome of the complexity level, then we can design environments to be equally satisfying. In other words, from this perspective man has no special need for nature; his mental health could be as well served by appropriately contrived substitutes in the man-made environment.

The issues raised here take on a particular urgency given overpopulation and environmental decline. Scientists in several fields have argued that the limiting condition of man's survival may be neither food nor oxygen, but sanity. If indeed man is likely to go out of his mind before he runs out of any of the traditional basic requirements of life, then a close look at the conditions and environments that are sanity-preserving and even satisfaction-enhancing seems essential. One facet of this issue is simply that of what man likes and why. The central hypothesis of this paper is that man has a preference for the visual patterns characteristic of natural environments, and further, that this preference is not reducible to the complexity of the stimulus array. (The brief description of the empirical study that follows is based on an honors thesis carried out by the second author under the supervision of the first author.)

Slide Study

The basic strategy of this study followed the dimensional methodology proposed by R. Kaplan (1971). The starting point was a population of color slides of common outdoor environments. They were non-spectacular in either content or composition, since the hypothesis of the study concerns relatively ordinary everyday environments. A group of judges categorized each of these slides into one of the following four categories: "man," "man and some nature," "nature and some man," and "nature." Based on these judgments, 56 slides falling about equally into the four categories were selected. These slides were rated by 88 subjects on a five-point scale for each of three variables: preference, complexity, and excitement-intrigue.

These data were then subjected to a non-metric factor analysis (Guttman-Lingoes Smallest Space Analysis III, cf. Lingoes, 1966; 1967) for each of the scales rated by the subjects. In order to test the hypothesis that preference for nature cannot be accounted for on the basis of complexity ratings, it was necessary to identify a set of material that clearly represented nature and a set that clearly did not. To achieve this, a stringent criterion was employed: the nature set consisted of the 23 slides which loaded on the nature dimension for each of the three rating scales; the 13 urban slides likewise had to meet such a triple-criterion. While the judges' classifications provided a sampling basis for the study, these did not necessarily determine the dimensional structure used to select the critical slides. In fact, the strong nature dimension which did emerge included slides from both "nature" and "nature and some man" categories from the judges' original classification. There was a clear non-nature category that unequivocally deserves the name "urban." The remaining slides did not generate a clearly defined dimensional structure, suggesting that much more extensive sampling of the suburban domain will be necessary if this aspect of the outdoor environment is to be understood.

Results and Discussion

Before looking at the role of complexity in man's preference for nature, it is useful to determine if nature slides are in fact preferred. The results leave no doubt about this. Nature material was so vastly preferred over the urban slides ($t=8.45$, $df=34$, $p < .001$) that the distributions barely overlap. In other words, with a single exception, the least preferred nature slide was favored over the most preferred urban slide. It might be argued that the selection of the urban material in contrast to the suburban material might have biased the results. Since the suburban slides contain a substantial nature component (comprising much of the "man with nature" category) this might be a confounded test. Nonetheless the suburban material (based on a less stringent dimensional criterion) was the least preferred of all our material. The mean preference rating for urban and suburban were not significantly different. The ranges in the means were: 1.24 to 2.40 for suburban, 1.51 to 3.70 for urban, and 2.67 to 4.38 for nature -- on a 5-point scale.

There remains, then, the crucial question. Can the complexity ratings account for the preference of nature slides over urban slides? As is clear from Figure 1, they cannot. Complexity did indeed account for preference within the nature domain ($r=.69$) as it did within the urban domain ($r=.78$). But nature slides were greatly preferred over urban slides even though the latter were in general rated more complex. (The correlation between the two ratings for the nature and urban slides combined is -.06.)

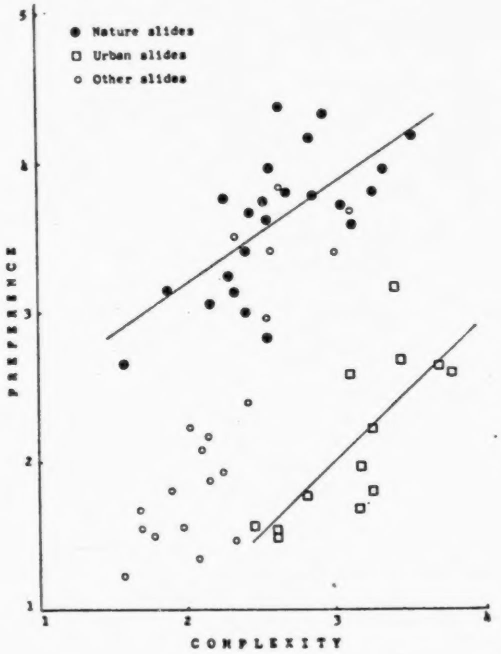

Figure 1.

The central finding of this study is, then, that while complexity plays a role in preference, it is not the only variable nor necessarily the most important variable in accounting for preference. And it does not account for the preference of nature over non-nature. Since this finding appears to be at odds with Wohlwill's findings, and since Wohlwill's paper promises to be highly influential in this area (e.g., cf. Craik, 1970), it seems appropriate to examine this discrepancy with some care.

With respect to preference responses, Wohlwill (1970) stated,

> ...the present writer (Wohlwill, 1968a) has demonstrated that responses to photographic

> slides of the physical environment vary as a function of the judged complexity of these scenes in much the same fashion as do responses to artificially constructed stimuli varying in complexity. (p.305)

This rather strong statement, however, does not appear to have received substantial support from the data he cites. The 1968 study suffers from sampling problems. Only 14 physical environments, representing seven levels of complexity, were used. The fourth complexity level, showing the highest mean preference values, is represented by two slides, "Lake scene with partial view of shore" which received by far the highest mean preference rating, 6.00 (on a 7-point scale), and "Key Bridge over the Potomac," which was tied for eighth place among the 14 slides in terms of its mean preference value. By far the lowest preference rating, 2.3, ("Factory and downtown area of small city") appears at the adjacent complexity level! In view of these large variabilities, it is questionable both whether the slides were truly representative of environmental settings of those complexity levels and whether complexity actually accounted for the preference values. In fact, in the earlier paper Wohlwill acknowledged that the unbiased correlation ratio for complexity and preference was not significant -- a finding he attributed to only two slides being available at each complexity level.

Using a substantially more adequate sample of slides we find neither the inverted-U relation assumed to obtain between preference and complexity nor any indication that complexity operates in a systematic fashion across environmental domains. Clearly one could select from Figure 1 a choice set of slides to support almost any hypothesis about the relation between these two variables that one might desire. With the complete set of stimuli, however, the outcome appears unequivocal.

A Tentative Model

With complexity reduced to the status of an important but not all-important variable, the status of theory in this area is left rather unclear. Based on some interesting clues in our results and the informational approach to environmental psychology proposed elsewhere (S. Kaplan, 1972), a tentative theoretical framework for research on the dimensionality of the visual environment is presented here. This conceptual structure gradually emerged as we attempted to understand subjects' reactions to a variety of slides, including those described here.

It appears that people's preferences were based on three major aspects of the scenes they were viewing. They prefer settings they can make sense out of, those they can comprehend with dispatch. They also prefer scenes that promise additional information. Finally, they react favorably to a whole range of particular features of the landscape, such as water and paths. We have designated these three aspects, "legibility" (after Lynch, 1960), "predicted information," and "primary landscape qualities."

Legibility. This category includes variables that aid the rapid transmission of information about the scene in question. Being able to decipher a scene quickly and without undue effort is essential for effective action and thus may have been a major factor throughout human evolution. We have found two components of legibility, that is, two ways in which rapid information extraction is facilitated.

Identifiability involves making sense out of what is depicted. This is akin to the rule that "form follows function" and is evident in the designer's concern to make a playground "look like a playground."

Coherence is the extent to which the scene "hangs together." Redundant elements, textures and structural factors can greatly facilitate comprehension. These all aid what might be called "micro-prediction" in that they allow one to predict from one portion of a scene to another.

Lynch's use of the term "legibility" may seem slightly different, probably because he applied it to a problem of a different scale. With respect to the cityscape, he defines legibility in terms of the "ease with which its parts can be recognized and can be organized into a coherent pattern" (p.2-3). Comparably we distinguish identifiability and coherence as the components of our legibility concept. What may be a "part" (say of a city) for Lynch would generally be the entire scene given our material. Thus a scene often has a "coherent pattern" simply because it is recognizably a house or a building.

But preference for settings and pictures is not only a matter of the immediate sense one can make out of it. It is not the case that one always prefers the scene that is the most obvious. Coherence can be so exaggerated that the picture might be called overstated. Even beyond that, there is something attractive about situations where one cannot quite tell what is going on. This is the domain of the proposed second category of determinants of preference.

Predicted information. This second category deals with information not nearly as readily accessible as that in the first category. It concerns information that one can predict would be available, that is, with the promise of future information. Once again, there seem to be two components, two ways of obtaining the promised information, one based on a different vantage point, and the other on additional time.

The first component of predicted information identified thus far seems on the surface far removed both from the landscape preferences and from informational considerations. When we first observed the operation of this variable we called it "mystery," and although our understanding of the concept has deepened since then, we have not yet come up with a more appropriate designation. A landscape with mystery is one where the path turns and disappears around a bend, leaving the observer unclear as to its destination. A brightly lit field incompletely glimpsed through foliage provides another example of mystery. In both instances there is promise that further information could be obtained if the observer could walk deeper into the scene.

Complexity, the other proposed component of predicted information, does not depend upon the predicted results of the change in vantage point. Rather, it promises further information upon careful inspection, a greater expenditure of time.

Since man has long depended upon knowledge for survival, the promise of further information would necessarily be attractive. This concept might clarify the notion of "ambiguity" proposed by Rapoport and Kantor (1967). Taken literally, "ambiguity" might merely be a blur. Presumably a more specific promise of additional information is generally necessary. At the same time we have no argument with their premise that providing too much information will often reduce attractiveness.

Legibility x predicted information. This apparent conflict between the desirability of providing information and the desirability of withholding it can perhaps be resolved by the two-factor approach proposed thus far. Clearly both legibility and predicted information are important in landscape preference. Further, the landscape represents sufficiently diverse patterns of information that both can be and often are present in the same setting. A frequently encountered source of coherence is the definition of foreground through texture; mystery, a predicted information component, tends to appear in the background. But while these instances show how these two factors are compatible, they do not define loci; identifiability and complexity can appear at any distance. Clearly, further research holds promise of greater insight into these entangled components.

It is suggested, then, that legibility and predicted information are independent dimensions of the visual environment, each concerned with informational aspects of the setting. Legibility is greater when one can figure out what is going on, and this is a function both the ease of "identifying" the scene as a whole, and of the "coherence" or redundancy of the component elements. Predicted information, by contrast, is concerned with uncertainty or lack of predictability, and is enhanced by both the "mystery" and the "complexity" of the setting.

There is a rough sense in which both coherence and complexity refer to first-order or cue-based information while identifiability and mystery are more inferential, requiring cognitive activity that goes well beyond the pattern of the stimulus array. The table below summarizes this proposed categorization.

Source of Information	Degree of Inference Required	
	Little	More
Present (Legibility)	Coherence	Identifiability
Future (Predicted Information)	Complexity	Mystery

Primary landscape qualities. The third category of influence on preference is not an informational dimension and in fact not even a dimension but a set of primary landscape factors. These factors include visual patterns or elements which have evolutionary significance. Masses of foliage and water features in the landscape provide excellent examples of primary landscape factors. Indeed even nature content per se, as indicated in the present study, may involve such special features. On the other hand it could turn out that these qualities are reducible to more basic variables such as textures and colors. This remains a challenging research problem.

The fact that our understanding of these important qualities is admittedly limited does not give us license to sweep them under the rug. Rather, we should be alert to their influence. Certainly, from a scientific point of view, keeping close track of them is essential if meaningful categories are to emerge. There is also a practical consideration that requires a balanced viewpoint. In recent years scientific information has become increasingly influential. Under such circumstances, temporary theoretical oversights can all too readily become the basis for policy.

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Note

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CHILDREN'S IMAGES OF HOUSES: A PROLEGOMENA TO THE STUDY OF WHY PEOPLE STILL WANT PITCHED ROOFS

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The House as a Progressively Constructed Symbol

In a recently published and praiseworthy article, Clare Cooper (1) expresses discomfort with sociological surveys of responses of people to the design of their houses. She confesses to a gnawing and troublesome feeling that these expressions of attitude do not begin to penetrate the layers and levels of meaning of house-form as psychological, social, or cultural phenomena. House-form is not a collage of conventional signs elected by the consumer like choices on a Chinese Restaurant menu. Each in his own way, Lord Raglan (2) or Mircea Eliade (3), Gaston Bachelard (4), and Karl Jung (5), have pointed to universal impulses which provide the spirit underlying the diverse manifestations of the house through culture and history.

The house of these analyses is portrayed as a marvelously balanced double image of that prelogical and archaic impulse to state one's terms of relation with the vicissitudes of nature. Thus, the house is both a means of standing resolute against the literal power of floods and storms, and a statement of resolve to fend off symbolic forces of evil and chaos. The hearth within it is both a literal center of family existence, and a liturgical symbol of the families' spiritual solidarity as the formative unit of society. Through ritual and ceremony centered on the house, loyalty to the family is enacted. Loyalty to any social group is based on "moment-to-moment social avowals" (6) in the form of shared symbolic recognitions. These rituals are special forms of behavior through which people mean or intend social relationships. In general terms then, the house is a mediating process of affirmation and denial, a medium for statements of allegiance and expressions of need. When it ceases to serve these living functions, it becomes as devoid of meaning as the loquatious terminology of the British bureaucrat or the "word-salad" of the chronic schizophrenic.

The purpose of this paper is to identify some landmarks in the development of children's ability to express their concept of the house through drawing. As one watches children of different ages construct the house of their imagination, it calls to mind the fact that the real dwelling house of the family is a progressively constructed symbol. The family discovers its identity and its rules partly in response to the form of the house. At the same time, the family builds, decorates, reconstructs, and selects the house as an expression of its unique needs and objectives.

The house contains a key to mastery of the complexity of the family for the child. Every step he takes toward deciphering the functions and principles of organization of the house brings him closer to articulating the structure of social roles in the family. For the five or six year old child, the house has no unity other than as a collage of objects and events that share an emotional tone gained through common participation in ritual activities of the family. At about this age certain very elementary socio-spatial distinction may be understood, e.g., the strictly private space of the parent's room, or the child's own personal space and objects. Primitive jurisdictional distinctions may be introduced in the form of tacit or explicit rules, i.e., the child cannot watch TV in the living room when father is reading the newspaper. But the house for the child of this age remains largely anarchic; it is a socially and functionally amorphous envelope. The social symbols which we take for granted (fences, doors, landscaping), are mere objects of play, experienced as having a significance no greater or less than all other objects on the landscape.

Slightly older children (eight to nine years) begin to recognize general properties of the scenario played out by the family. The child becomes aware of parental roles and family lifestyle as he becomes aware that the parents themselves make an effort to meet the standards of a third party, "society." For example, the parents behave differently in the presence of friends, relatives, and neighbors as visibly expressed in dress and demeanor, cleaning, welcoming, and exchanging courtesies. Through these parental acts, the child begins to have a dawning awareness of the social order of the home, and the surrounding neighborhood.

At ten or twelve years children have fully assimilated rules of the socio-spatial order of the home and the structural organization of the family. They take special delight in entertaining guests or visitors in the home, demonstrating the finesse with which they can use the front door as a ceremonial threshold, gently guiding guests into and seating them in the living room, offering them coffee and chattering about the decor. They begin to adopt a proprietary interest toward the ceremonial areas of the home, or the decoration and repair of their own room. By this age socio-spatial rules have become sufficiently abstract and systematic so that appropriate behaviors can be generated as they are needed in a wide range of new situations, without need of rigid conventions.

Muchows' (7) interview studies of the child's perception of the city revealed similar pictures of the pattern of progressive adaptations. For example, she studied how children behave in a busy department store. For the six-year olds, the store is a huge field of action through which he can wander and in which he can play games. Stairs, escalators and elevators are of central interest with almost no attention paid to the products themselves. The department store and its contents are for the child what he can do with them, just as a fence, rather than being a barrier to further penetration, is something to climb on and over, balance on top of. For the nine-year olds, the department store has shifted in meaning to that of a huge fair or stage. He collects samples of miscellaneous goods and information that are unrelated to the central function of the store, but nonetheless, operate as mementoes of the complexity or vastness of the store. He comes home with advertising circulars, rubber bands, a store-name pencil, and maybe even a list of prices of things he saw. Finally, for the young adolescent (twelve years), the department store is a microcosm of the world of adults. A group of girls will conspire outside a store on how to behave inside, and then take joy in trying on clothes, acting in ways that will result in their being treated as adults and addressed formally (Miss - - -). This is their nexus with the adult world of economics, anonymous social relations and public demeanor (Werner, p. 388-9).

In this small example, we begin to see the nature and vastness of the transformations that have to occur for the child to experience the spatial setting of the home, the school, or other community facilities as microcosms of the larger social order. In this process he begins with enactive knowledge, organizing his world as a collage of events linked together by virtue of their participation in the same set of activities.

At a second stage (iconic knowledge) the child begins to sense the meaning of the home as a stage setting for different activities, e.g., intimacy, discipline, or formal entertaining. Finally, at a symbolic stage, the child begins to experiment with defining roles for himself to play in the families relation to the home environment. Border and boundary rules are established as the child fights for jurisdiction. The street festival atmosphere of the home gives way to a view of the home as a microcosm of society. At the symbolic stage children have developed the capacity to incorporate the environment into adult patterns of sociality. Because they may not be able to conceptualize principles, these early attempts at decorous or gracious behavior are likely to be clumsy and stereotyped.

As they develop social and sexual interests outside the family, there is growing consciousness of choices in the way they can present themselves to strangers. They have been aware, for some time, that life-style and demeanor in their own home contrasts with dominant expressive styles in the homes of friends, neighbors, or relatives. Further, they have been aware that manner of dress, decoration, and demeanor is a flexible norm, shifting in meaning from situation to situation. With consciousness of the rules through which these effects are manufactured, comes the ability of the child to invent his own public face.

In the course of child-development the built environment undergoes a significant psychological transformation. At first, environmental objects are measured in meaning only against the standard of the child's body and the forms of play into which features of the landscape can be incorporated. If objects suggest social behaviors or attitudes, it is largely due to accidental association with past experience. For example, at this age children respond with appropriate caution to the signal of danger provided by the street edge, but this "margin of safety" behavior will not generalize to other social indicators (e.g., portals).

As the child's conception of the structure of the physical world ripens, he begins to respond to elements which more closely reflect the rules of division and composition applied by adults. Large classes of objects (e.g., doors) evoke a distinctive pattern of actions, e.g., knocking on doors, the use of keys and locks, employing posture and body position as a way of blocking passage or indicating deference, responding to the structural composition of the house-system as a set of relational units (path and door, door and window, windows and floor, stairs and floors). Finally, and only after ten or twelve years, children conceptualize the semiotic structure of house-form separating primary (denotative) from secondary (connotative) meanings.

A triumphal arch and a crude wooden door can have the same primary function (both are portals) differing radically both in physical structure and in their secondary function. Furthermore, secondary features of objects come to contain statements of social ideology or "ideology of living," e.g., a large heavy door evokes unique behavioral expectations different from those evoked by small lightweight doors; a throne-chair implies being "seated with dignity" while a standard chair comes to connote "seating with informality." At this state, objects function as the symbolic vehicle for more explicitly shared social representations.

At home, the child remains largely the son or daughter of the family. Away from home he begins a process of deliberate experimentation with expressive enactment, responding to a vocabulary of expressive forms first encountered in the home. The child's public personality emerges as a distinctive configuration of styles, preferences, and tastes which are self-selected. Some children stay close to the model of appearance and demeanor encountered in the home. As a result, their behavior in the outside world elicits responses which confirm pre-established expectations. Others deliberately experiment with the range of personalities they can become, carefully assessing what it was that they did, wore, or said which brought forth these varied responses. The change in appearance, gait, and composure which results from the development of secondary sexuality produces a rather dramatic transformation in the way children are greeted by the public eye.

This radically new response induces the child to appreciate the social meaning of appearances. Where in the past, there was no reason to question the decor of the living room or mother's style of dress as defining the ideology of living of the family, the child now begins to disaggregate primary and secondary meanings. The mock Colonial house is seen as expressive of "traditional values," the overstuffed couch becomes indicative of informality, the manicured lawn becomes a trademark of conformity. The child's moral rage with parents at this stage results from the recognition that these expressions of attitudes and expectations were chosen by the family from a range of possibilities, the scope of which the child can just now begin to appreciate. They represent moral choices as well as personal aliments; they state terms of relation of the family to the world beyond. Corresponding to this recognition is a new awareness of social class. Indeed, at this stage the adolescent may become curiously aware that one cannot "tell the book by its cover." Not all appearances or life-styles are based on choice.

It is important to recall that environments have no norms of history, no conceptions of relative value for young children. These secondary features are identifiable only after he can distinguish between voluntary and accidental features of the environment; i.e., those which are defined by human intentionality (e.g., the spinning wheel which has been revived to serve as the base for a planter), and those which are accidents of aging, deterioration, or chance combination. Analogously, the child must overcome a magical belief system which suggests all features of the physical surrounding of his own home have a sacred history and a sacred purpose. This realization goes hand in hand with the developmental shift from a heteronymous morality to autonomously generated moral values. Needless to say, the same development takes place with regard to the "plan" of the church, the library, the school. In each instance, the child now begins to appreciate how individual and group actions disrupt or help to reinforce the secondary meaning of the physical setting. Rules of behavior are seen as personally defined avowals to accept or deny intention expressed through the physical environment. The child desists from throwing paper on the street, not because it is wrong by definition, but because he has now come to share in the adult definition of form and meaning of the street. First, he appreciates the social and aesthetic consequences of littering; i.e., dirty streets are a sign of social decline; second, he recognizes that continuing human effort and intentionality are an integral part of the definition of secondary meaning of the built environment.

The Ontogenesis of House Drawings

In traditional societies children sense the existence of the group through limits established by patterns of scars, body mutilation, or costume; it is not until they understand the formal ritual or the historical legacy through which these identifying signs have emerged that their true meaning is revealed. Ultimately, identification with the group is not a matter of bearing prescribed appearances; it is an avowal to the group expressed through the voluntary act of taking on an appearance which signifies that commitment.

In modern societies the process is similar but the means of expression of avowal are more diverse, variable, indefinite, and sometimes more abstract. The young child's evolving view of his own development leads him to assume he will become an adult, and a particular kind of adult. But his vision cannot decipher the conceptual meaning of the elements of his parents' appearance and life-style. This lack of conceptual understanding does not prevent him from responding "as if" he knew the meaning of the patterns of politeness and decorum he observes. He assumes that the entertainers' smile is his inner life, no less a mirror of his state at the time of birth than his hat and cane.

The picture of the happy clown with a tear in his eye is compelling because it marks a transition. Through irony, the child learns that appearances are merely a medium against which to play revelations of inner life; they are not a direct reflection of personal needs and commitments. The generalization of this principle requires long inquiry into the structure of appearances. Years of careful observation are required before the child can differentiate deliberate expressions of inner life from those manifest qualities which reflect conditions out of the realm of control of the person (race, signs of poverty, peremptory conventions of the middle and upper classes).

Early stages of this inquiry into the structure of appearances entail very simple questions. In the case of the expressive meaning of the house, for example, the six-year old child has first to learn which features are fixed and which are variable and thereby capable of carrying the burden of expression. For young children, the concept of the house is an inextricable unity of primary and secondary meanings.

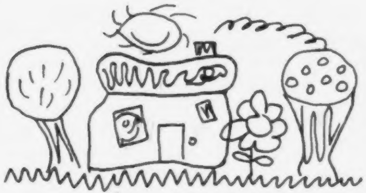


figure 1

It would be wrong to interpret early schematic drawings of the house (see Figure 1) as "form plus expression." The indications of grass, trees, and flowers are as much a part of the spheric concept of the house as are the wobbly lines which define its lateral containment. It is almost impossible to get a child to draw a house without including some features (e.g., person, chimney smoke, doorknob, sun), which seem to the adult mind like extraneous atmospheric decoration. That which is variable for the adult is relatively fixed for the child.

Alternatively, the child shares with artists the capacity to effectively depict expression by varying those features of house-form that most adults take to be fixed.

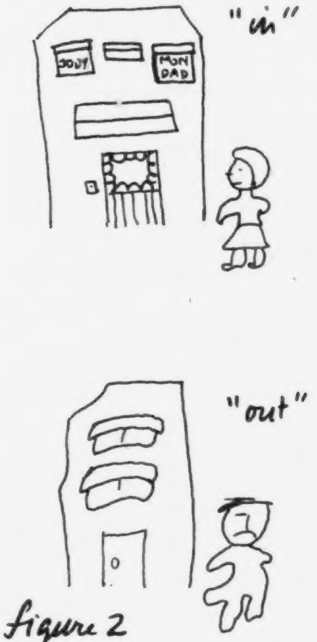


figure 2

Unencumbered by conceptually guided means of establishing identity, form is plastic and can be used freely in the service of expression. In Figure 2 the child was asked to draw someone "entering" and "leaving" the same house. The expression of "entering" is conveyed through signs of anticipation. The "leaving" picture looks like a different house; its gaiety has been lost by removing the decor, the windows echo the downturned mouth of the agentive figure. The child feels no caution in modifying the primary structure of the house to achieve these expressive effects.

There are many instances in our culture where new unities have been created through a process of addition to or magnification of older, more stable forms. Early luxury apartment buildings, for example, attempted to incorporate in their enlarged form many of the features that would have been present were individual homes stacked one atop the other; in this process, new and stable schemes of living were generated, supplanting the individual family house and following their own line of development. Other examples of synthesis with which children feel familiar are the castle (house of kings), the barn (house of animals), the church (house of God), the fortress (house of the army).

Children's drawings reveal that beneath surface recognition of the existence of these complex forms is the ghost of the archetypal individual family house.

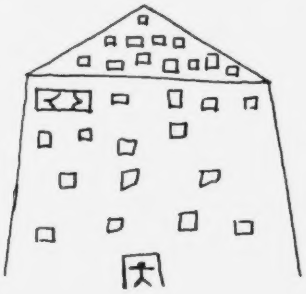


figure 3

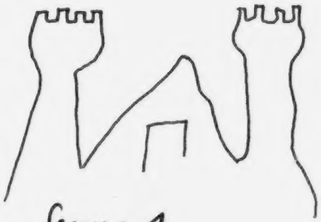


figure 4

In drawing an apartment building (see Figure 3) an eleven-year old boy persists in including the peaked roof and the curtained picture window. In a faltering attempt to draw a castle, an eleven-year old girl (see Figure 4) recognizes but cannot resolve the incongruity between the towers and the peaked roof.

Since tall buildings are not understood in terms of their constructional principles, the child assimilates their form to the stable scheme of the single family house. The notion of stories implies the presence of a syntactic code with respect to buildings.

The child's conception of constructional science is largely confined to the post-and-lintel forms he creates in his block play. To understand the structure of tall buildings requires an abstractive leap. Until the child can conceive of the tall building as a structural network of steel and concrete, the concept of stories remains enigmatic; these visible marks on the building surface are seen as partly structural and partly decorative. Furthermore, the new elements of construction (beams, slabs, vaults, piers, plates), have no psychological meaning.

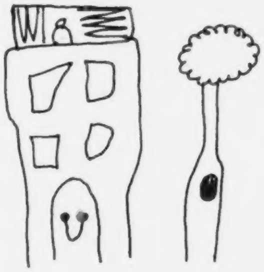


figure 5A

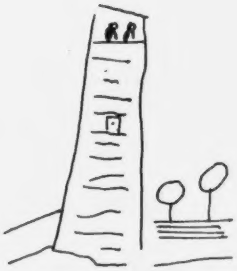


figure 5B

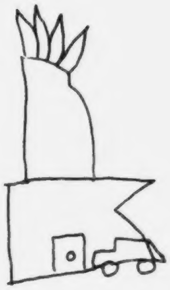


figure 5C

Riverside Church in New York combines properties of both church and skyscraper. After a trip to the bell-tower with a group of five and six-year olds, they were asked to draw the building (see Figure 5 a, b, c). Clearly, while children experience the building's height, the use of stories to represent height is inconsistent. Until building height becomes organized as a structural-functional system, expression of connotative meaning through variations in height will be vague and diffuse.

For these children virtually all elements are free to vary. Note the casual manner in which a nine-year old girl (see Figure 6) changes the number and arrangement of windows in a drawing of her "entering" and "leaving" the same house.

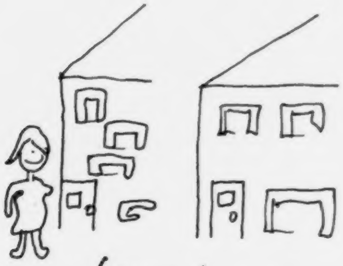


figure 6

What is especially compelling is that the placement of windows is not constrained by concern for the number of stories implied by the drawing. Indeed, their positioning is motivated almost entirely by the visual Gestalt provided by the external border. If the outline changes accidentally (e.g., expands), the windows are placed differently to cover the empty area.

As the child's appreciation of constructional means is developed, small variations in placement of windows on a facade can take on delimited expressive meaning. Constructional principles provide the grammatical context in which variable figurative expressions are possible. The grammar of language defines the meaning we give to words, allows the ordered introduction of words specially designed for expression (adverbs, adjectives) and frees up other channels of communication (intonation, stress, tempo) for expressive uses.

A drawing of an apartment building by an eleven year old boy represents an interesting transition between concern with window placement as mandated by the formal-Gestalt context, and the recognition of window placement as determined in large measure by the structure of the building (see Figure 7).

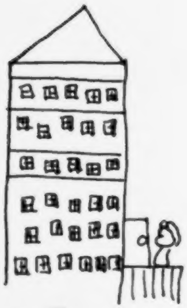


figure 7

Stories are indicated in the drawing, but they do not define equal units. Windows begin to imply a vertical structure, but they are variable in number, and only approximately lined up in the horizontal dimension.

Another set of distinctions the child has to make in deciphering the origin of appearances concerns the structure of function. In the early years the environment is a tableau of vaguely interdependent objects. There is no need to ponder their logical relations (e.g., whether a knob is to a door, as a door is to a house). Both elements (door and knob) are entailed in and subordinated to the act of entering the house. Part of the form of the house is, however, determined by its functionality as a machine for living. The knob is placed at a particular position and is a knob (vs. a hanging cord) as an expression of the way it is used. The form of the roof and the placement of the chimney relate to the functional spaces they frame within the house. The presence of other elements like dormers, terraces, domes, and stairs are primarily dedicated to functional requirements, e.g., providing connections between spaces, containing and enclosing spaces.

Until the child can perceive these functionally determined features of objects, he cannot vary them intentionally. The incapacity to reason about functional structures leads children to draw many curious anomolies like the chimney whose smoke comes out the other side of the building (see Figure 8) or the door knob that remains on the wall when the door is opened (see Figure 9).

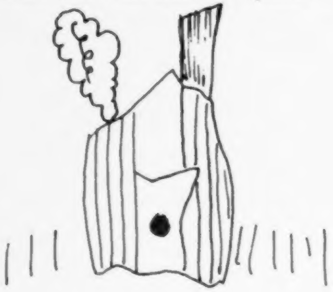


figure 8

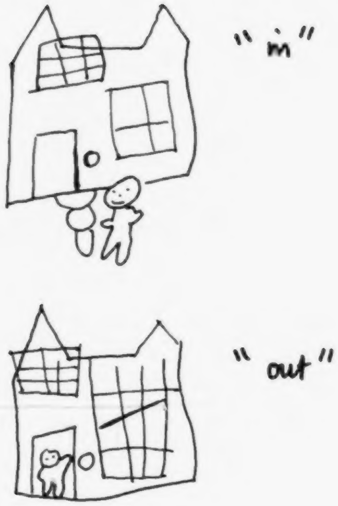


figure 9

Eventually, the simple scheme of the house gives way to a more complex functional scheme in which the structure of elements of the house and its surrounding context begin to reflect the function of the house-front as a means of gaining access; the path suggests a route, and the door is framed by windows which look out onto the path. A drawing of a nine year old (see Figure 10) conveys a sense of resolution of structure and function, not by adding complexity to the drawing, but by subordinating its parts to a system of behavior. This bears a striking contrast to other drawings in which the figure is immobile beside the house, or those in which individual parts are arbitrarily singled out for undue attention (see Figure 11).

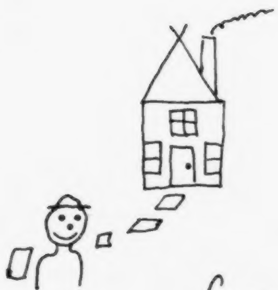


figure 10

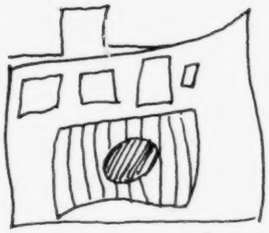


figure 11

True expression begins to emerge as a feature of children's drawings of houses at about age nine or ten. When asked to convey in pictures a "huge" house and a "tiny" house, younger children (six to seven years) generally express the contrast by drawing the same lines at two different scales. The houses are structurally similar with some random, accidental variations in the number of windows or stories. Interestingly, while the number of windows almost always varies from the first drawing to the second, it is as likely to increase as decrease. As the house gets bigger or smaller so does the person, the trees, the path, and the sun. The tendency to draw "tiny" houses at a smaller scale persists well into adolescence. Adults, of course, are able to convey the image of a large house or a small house at any scale of drawing.

At nine years children begin to introduce stereotypes of small houses as a means of expressing size with relative independence of the drawing scale. The earliest scheme of this type to be introduced is the doghouse (see Figure 12).

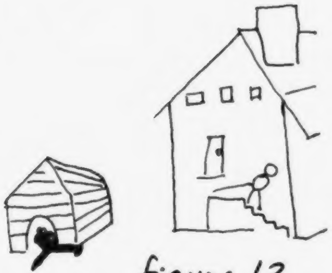


figure 12

More typically, nine-year old children draw outsized or expressively exaggerated forms. Hugeness is expressed by means of contrast between the two drawings, but now the emphasis has shifted from comparative linear size to differences in internal relationships. For example, the door of two houses remains the same size but the outline of the large house is twice the size of the small house. Even this simple mode of contrast is not achieved without confusion, in some drawings the "huge" house is larger and has a bigger door; the "tiny" house is smaller but instead of the door remaining of fixed size it becomes still more diminutive.

At age eleven children begin thinking of hugeness in terms of more complex building types such as the castle, the fortress, the manor; tininess is conceived by means of images like the shack, the dollhouse, the cottage, and the doghouse.

In addition to these sterotyped forms, some children begin to appreciate the expressive potential of elements of the ordinary house (e.g., stairs, doors, roof) and the quality of line and shading of the rendering itself. As size becomes depicted directly through quality of line and the expressive tone of the elements (see Figure 13, 14), it becomes independent of the scale at which the drawing is done. By analogy, the Gothic cathedral nestled in the shadow of giant skyscrapers can appear to reach higher to the heavens than its neighbors. At first these depictions may require the added artifice of labels (e.g., "James' Manor") or classical forms (columns) to reinforce their meaning. Eventually, the full measure of secondary meaning is expressed exclusively through the manner in which primary forms are handled.

figure 13

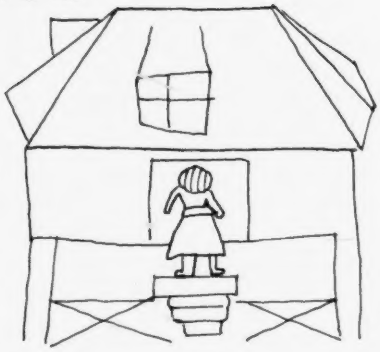
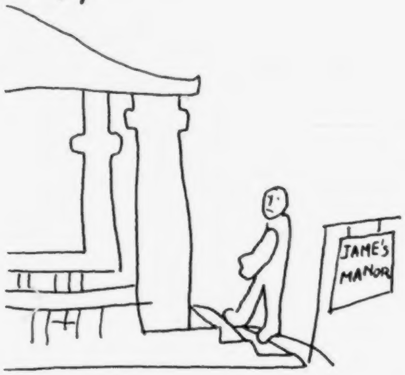


figure 14



Summary
At higher levels of functioning the rendering is guided by a dialectical outlook. The child is oriented toward the discovery of rules immanent in the drawing medium itself. Further, he is concerned with the shaping of ordinary forms, and the invention or discovery of new forms to serve specific functions. In addition to signifying the primary function of the house, the rendering now makes a second order statement about all houses. When the child looks at a house he sees both its form and a statement of purpose made by its architect and the person who inhabits it.

The house is no longer a one-dimensional expression of self. It is an expression embodying varying degrees of commitment, sincerity and truth. The child can now judge the content of expression separately from the effectiveness with which it is portrayed. To the sophisticated eye, aspects of expressions which reflect personal or cultural style are distinguished from those features of expression reflective of the level of aesthetic development of the user or architect.

Corresponding to this shift is a change in meaning of the "house as symbol." Rather than being an emblematic expression of family life which the house bears on its surface, it becomes a self-conscious avowal or denial of the significance of ideal norms (equity and reciprocity) implicit in the concept of the family.

The mobile hippy house-on-wheels (converted buses or trucks) and their more fanciful counterparts (e.g., Archigram's "Instant City") are statements which explicitly express an attitude toward the nature of habitation in society at large. Human intention and consciousness of choice is indicated by carrying the theme through in every detail of physical form.

This kind of architecture, by itself, has no capacity to enlighten, enrich, or change the person. It is the person who through architecture realizes his capacity for choice and change. If architecture has a responsibility, it is not to invent new, more humane styles or to placate culturalist impulses by providing new emblems of group identity. Rather, by providing challenges to schemes of living which have sedimented out, the architect can contribute to an awakening of consciousness of man's relation to man, and man's relation to Nature.

The study of children's drawings of houses is viewed as assessing the strength and psychological history of the enemy within; the unwillingness to surrender old schemes of organizing and structuring life for new, more experimental, open-ended means. Inasmuch as the architect's task is to make evident the constructional, and functional systems of buildings, he does society a tremendous service when he does it well.

Were I to state a goal for the next generation of architects on the basis of these ruminations it would be to invent new means of making evident the contribution of the political and institutional environment to house-form; and, to help people discover their own moral values and societal commitments through interacting with environments that reveal in their form the personal, moral, social, and political concerns that inspired their design.

These values have been ingredient in past generations of great public architecture. The problem of expression was less profound in the high Renaissance, where the picturable template of Greek and Roman society provided an inexorable bond between the form of buildings and their public or social meaning.

With the introduction of recognizable, alternative conceptions of government, the suitability of classical forms was called to question as a singular expression of all means of construing the social order.

This process involved more than a mere waning of taste or a tiring of the eye to the styles of antiquity; it entailed a cognitive distinction between fixed and variable properties of the physical environment, a symbolic distinction that may not have been possible prior to the Renaissance. Just as knowledge of simple elements of construction aids the child's growing awareness of expressive properties of the house, the origins of science and technology provided the Renaissance with the philosophical distinction between primary and secondary properties; it liberated styles from their classical embodiments.

Through this aegis, the built environment became an intentionally framed, symbolic expression of the social order: a way of stating propositions about society. As a plethora of new styles emerged, each reflected the wisdom of antiquity while hypothesizing new values, new conceptions of the relation of man to man through diverse forms of appearance.

Now to root this distinction in everyday reality. Whether one prefers a ruralist, suburban or urban life-style is a matter of taste; whether one can elevate to consciousness the inner forces or traditions which motivate these choices is a matter of cognitive development. Finally, whether in fact these underlying forces are elevated to consciousness is a function of political and social conditions beyond the scope of the individual.

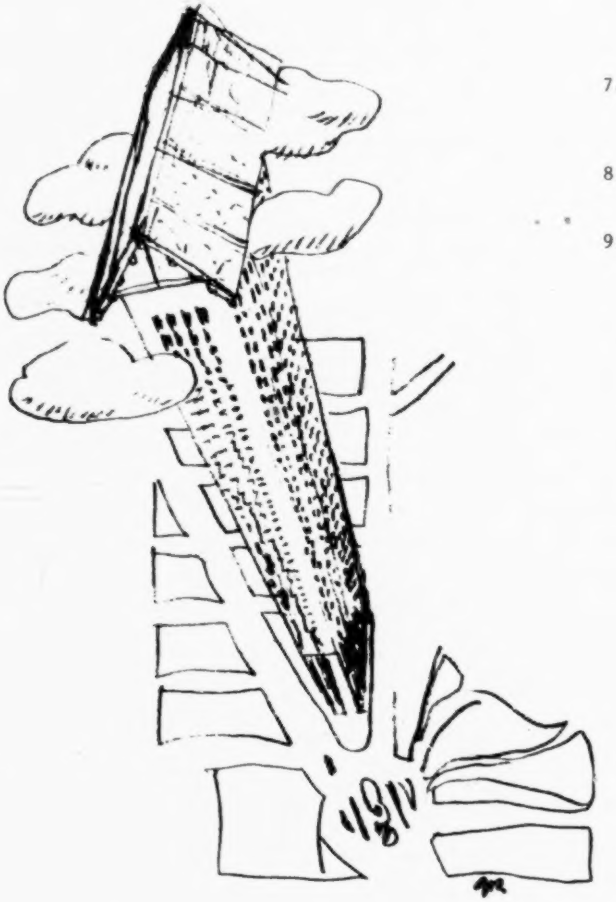
The architect has in his palette elements of form which can communicate dialectical meaning; he can design environments which make simultaneous statements about the design of all environments, or even a statement about the human capacity to make statements. In conventional design, the architect does more than merely frame felicitous spaces. He implies ways in which the house should be used as an instrument of social action; he defines the actors in the drama, the scenic background of their actions, and to a great extent, the nature of their purposes.

In good architecture, he leaves small clues, structural messages, which communicate to the user the architect's past presence, his design choices, and his dialectical concerns. This message can be conveyed through the treatment of a corner or the relation of the building to the ground plane; in contemporary work (Venturi) the message is carried by means of over-scaled elements, or playful and surprising juxtapositions of purely symbolic elements with the more conventional forms. Through a dialect of expression, the architect reminds the user that the conventional setting is just as much a human symbolic construction as the crazy "far-out" cushicles and cubicles of modern design.

Beyond style, not all people are capable of the level of aesthetic and critical judgment necessary to engage in these symbolic dialogues.

Modern architecture has always represented a threat to those for whom the distinction between form and meaning has no relevance, e.g., those who assert it is not possible to conduct a proper family without living in an individual house and yard.

Despite its apparent conservatism there is an implicit wisdom in this security-seeking tendency. People do not wish to surrender a known setting, in which physical and social form work hand in hand, for life on a bare stage, where each individual actor is left to write his own social scenario. Modern designs which are insensitive to the cognitive complexity of writing this new scenario may conjure the appearances of a new life through physical form; on inspection one finds them to be just a scrim, a see-through painting of one more way of being selfish.



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VALIDITY AND RELIABILITY OF RATINGS OF SIMULATED BUILDINGS *

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How does one represent a designed environment before it is built? What are the right questions to ask about such a representation? Real or proposed physical spaces are notoriously difficult to model or manipulate experimentally, not only because they are expensive and time-consuming to construct but also because they are highly complex, their effect may be revealed only over extended time, and their connotations will vary with different kinds of self-selected users in variously-defined groups.

In a test of scales and simulations, the exteriors of 4 recently-constructed campus buildings were evaluated on five 7-point labelled scales by 2 control groups (N=38 each) of subjects randomly selected from a pool of 304 naive adults. Other equal-size groups from the same pool evaluated the same 4 buildings simulated by either 3-dimensional models, or color photographs, or black and white photographs. Some groups viewed each building from one position only, while others viewed each building from two positions.

In general, the 4 buildings rated high on some scales and low on others, and the different simulations did not much affect average ratings pooled across buildings. What the simulations did significantly affect (on all 5 criteria) were the relative mean values between different buildings.

This finding, if valid, bears importantly both on user preconstruction judgments between design alternatives and (often) on the post-construction selection of buildings meriting architectural awards. The architectural simulation is apparently not typically a psychological surrogate for the real facade.

Introduction and Overview

Research on the behavioral and aesthetic implications of architecture has been impeded by very considerable methodological difficulties.(1) Firstly, the unit demarking the independent variable (typically, an alternative design of a building or environment) is extraordinarily complex, so that it is most difficult to relate behavioral differences observed between alternatives with particular structural differences between them. Secondly, the effects of structure (of environments or buildings) on inhabitants may become manifest only over a very long time frame ... perhaps years. Thirdly, effects on inhabitant groups may be quite different from effects on individual visitors or clients. Fourthly, even if two structures are very similar in all but a few significant features, an investigator would be hard-pressed to establish that behavioral differences between their inhabitants are attributable to differences between the structures rather than physiological or psychological differences inherent between inhabitant populations who usually are self-selected ... people in social groups are "confounded," in an experimental design sense, with places. Finally, buildings, and other designed environments which characteristically surround their inhabitants while the latter move about within them, are most difficult to simulate in research laboratory settings.

Given these difficulties, most researches on behavioral results of architectural design are restricted to case studies. As in the early stages of scientific investigation of any field of natural phenomena, case studies provide insight into the range of aspects of human behavior which can be affected by environmental (and especially architectural) forms. However, except in isolated instances, such studies do not allow one to make assertions about which features of the environment are associated in a causative way with which features of observed behavior.

Given the difficulties of assessing the affects of complex structures, two paths are open. Firstly, a sufficiently large population of case studies, each applying at least roughly equivalent methods of evaluation to standard features of behavior, can be accumulated so that multivariate or cross-classification analytic techniques can be applied.(2)

Secondly, one can attempt to experiment with structures, either in full scale or real time or in terms of simulated settings abbreviated in time and space. Full-scale real time simulations are relatively rare. There are two kinds: the "natural experiment" and the full-scale mockup. Natural experiments are naturally infrequent, while still retaining many of the disadvantages of the case study. Full-scale mockups are expensive to create realistically and difficult to investigate because often the process of investigation itself reduces their realism.(3) Accordingly, behavioral scientists have turned to small-scale simulations which allow them to make practical application of the established experimental laboratory methodology of the behavioral and life sciences.(4)

Architectural Simulation

Small-scale representations, simulations and mockups of built places are the very "stuff" of architectural practice; in a sense, any time a designer sketches alternative forms and judges one is better than the others, he conducts a simulation experiment. The great difficulty is that one never knows whether responses to a simulated architectural environment (c.f., e.g., Ritter & Hibb, 1969) or conversely respondents' *expression* of environmental preferences through the manipulation of small modeling (e.g., on sandtable ... see Michelson, 1966) are the same as when architectural forms are expressed in full scale.

For example, when one views a model on a table, his perspective and the angle the model subtends at his eye are different from when he views the image at eye level. Sky-lighting, shadowing and the surroundings extending from the model or mockup may also lack verisimilitude. Because small-scale simulations typically can more readily be seen in their entirety from one viewing position, building designs may impart a greater sense of integration than would be inferred by a viewer at ground level. Perspective drawings or photographs may avoid some of these difficulties, but two-dimensional approaches to simulations of buildings and designed places, have other faults in addition to their inherent two-dimensionality.

Experimentation with architectural simulations become even more difficult when one is concerned with the *insides* of structures surrounding their occupants, rather than merely external facades (Langdon, 1970; Lau, 1970; Winkel & Sasanoff, 1970). And the whole question of the merits of simulations becomes extraordinarily complex when we begin to discover ... as we will ... that some simulations give good verisimilitude for some purposes but not others; thus in experimentation the simulation technique one uses will vary with the attitudinal, social or behavioral dependent variables measures, as well as the kinds of forms and spaces to be represented.

Yet simulation is vital to the development of a body of knowledge in architecture and planning which includes generalizations about how features of form shape human responses. Valid simulation also has great practicality, in that it permits one to have confidence in his or others' interpretations of the effectiveness of proposed designs (represented by small-scale modeling in two or three dimensions) upon human functioning. There are as yet no grounds for such confidence. To put it bluntly, all h'mmming and nodding of heads that occurs today when hundreds of architects present thousands of pretty sketches and handsome models to scores of thousands of clients' building committees is just as significant, and no more, as the ooh'ing and ah'ing of the same people at a noontime fashion show in a men's bar. The sole purpose of the exercise is sociological rather than critical, for the viewers are unskilled in reading architect's plans and the intentions expressed in his plans. Even where it is otherwise, predictions of what people *will* do in planned buildings (rather than what they are *supposed* to do) are rarely if ever corroborated.

Architectural Scales

A consideration of "architectural meaning" involves an attempt to define what we mean by "mean". Invoking Osgood's language of the "sign" and "significant", architectural meaning (like semantic meaning) involves the mediational links between the significate (the architectural display) and the signs used to represent it (the word descriptors to which we respond). However, the incautious assumption that a semantic differential applied to a stimulus *object* (building) yields equivalent information as a differential applied to a stimulus *concept* (word - itself a sign) may have led us to conclude yet unproven conjectures about the nature of architectural meaning. Osgood stands on firm ground in using a sign (word) to investigate meaning of another sign (word). As yet, no one in the environmental-behavioral disciplines has demonstrated a technique to study the meaning of a significate (building) via the medium of a "significant" differential. Pending such discovery, architectural "meaning" can only be investigated in terms of threads of unity found among multiple samples of respondents, investigators and procedures, through the emergence of similarly ranked loadings on common sets of dimensions gathered in a multiplicity of settings.

Despite inherent weaknesses of prior studies, a closer look reveals an emerging pattern of what constitutes architectural meaning. The most frequently referenced users of the semantic differential approach are Vielhauer (1965), Canter (1968), Hershberger (1969), Craik (1969), Collins (1970) and Janiskee (1971) (whose work is not yet in print). A compilation of the findings of these six investigators affords a look at their factor structures (arranged by rotated factor emergence).

There is noteworthy agreement among the six on the first factor. All find a factor strongly indicating *aesthetic evaluation*; but for none is the loading pattern identical to Osgood's semantic evaluation. Note that good-bad appears well down the ranked loadings, if at all. Also for four of the six, there is clear evidence of a confounding of aesthetic evaluation with activity (loadings on *dynamic*, *exciting*, *revolutionary*, *lively*, *active*).

The second factor emerges almost as cleanly for the six. All report high loadings on *neat*, *orderly*, *tidy*, *clear*, *stable*, *simple*, *calm*, *peaceful*, etc. Closer inspection of lower ranked loadings suggests that there may be some confounding of *orderly*, *tidy*, *neat* into *simple*, *rational*, *straightforward*.

Four of the six studies show a third factor related to size, but usually broken into separate components of physical size or phenomenological size. For Hershberger, *spaciousness* and *open* were confounded into Factor I; his third factor then reflected *strength*, *boldness*, etc. Janiskee did not include *spaciousness* but instead had a third factor relating to distance and accessibility.

TABLE 1

Factor Structures for Six Researchers of Environmental Descriptors*

	Factors I	 II	 III
Vielhauer	pleasant appealing inviting gay cheerful	neat orderly tidy organized clean	roomy free space uncrowded comfortable
Canter	pleasant interesting lively active	tidy clean coherent clear stable	spacious constant flexible
Hershberger	cheerful welcoming beautiful active exciting interesting (spacious)	ordered clear strtfrwrd. rational simple	strong bold profound rugged good
Craik	dismal distressing expressionless glamorous gay	calm cozy civilized	big huge elongated broad
Collins	interesting inviting dynamic exciting animated	peaceful quiet orderly neat secure	spacious roomy uncluttered open
Janiskee	interesting beautiful pleasant impressive	constant stable calm inflexible	near-far central accessible

Experimental Design

The major classes of factors which affect judgments about architectural space have been well summarized by Brunswick *et al*. (1943) and Craik (1968). Judgments depend on *what* (kind of) spaces are being judged, *who is* doing the judging, *what kinds* of judgments are being asked of the *judges*, *how* the different building spaces (stimuli) are represented (simulated), and under what conditions judges view the representations. The experiment described below attempts investigation of three of these factors.

The experiment focused on judges' responses to the overall exterior form of four different buildings on the University of British Columbia campus which were constructed within the past decade. Thus the study gave explicit consideration to the first factor discussed by Craik: the kind of space (facade) to be judged varies at four levels.

When building facades are being judged, it would be better if judgments were not contaminated by previous knowledge about the particular buildings. Fortunately, the University in 1970 hosted a tri-annual "open house" for the regional community, with many persons (e.g., parents) visiting the campus for the first time. These persons made good subjects for experimental purposes, both because they could give judgments based only on what is shown to them and because in most cases they came to the campus expressly to look at buildings as well as other things.

Thus the second factor of Craik (who is doing the judging?) was not varied. Judges were visitors to, rather than users of, the campus. They presumably were unfamiliar with the test buildings. The buildings tested were not differentiated to subjects with respect to purpose but instead were appraised under the rubric "campus buildings."

An advantage of full-scale or small-scale exterior models is that they can be viewed from various perspectives. However, small-scale mockups and full-scale representations are very expensive. Much cheaper representation can be obtained with plans, perspectives, elevations and sections. These in turn may be ineffective in inducing valid judgments; this failure may derive either from the fixed viewing perspective which graphic representations entail, or from their lack of three-dimensional depth.

The four test buildings were each visually represented to judges in four different ways: in full scale, in scale models, in color photographs and in black-and-white photographs. These various representations or simulations constitute a test of Craik's third factor: the way that buildings are represented to judges.

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*Collins, J.B. Scales for Evaluating the Architectural Environment. Presented at American Psychological Association Convention, Washington, D.C., September 3-7, 1971.

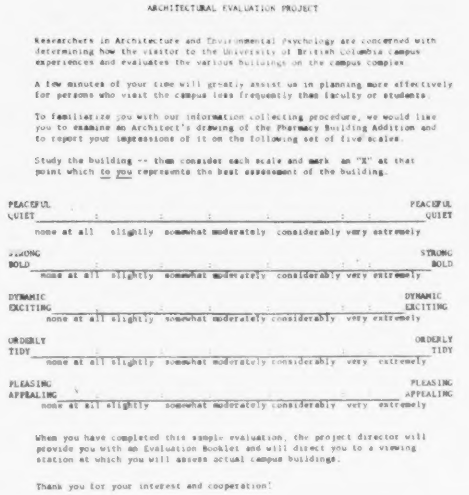
To provide a limited test of the fourth factor discussed by Craik ...the conditions of judgment with respect to simulation and viewing angle ...judges were asked to view real buildings or their three-dimensional models from one or alternatively two perspectives, which were also specifically those used in the two-dimensional photographs of the same buildings.

A final consideration raised by Craik is the kind of judgments asked, with respect both to quality and scale of measurement (e.g., rankings vs. ratings). Previous research suggests that people tend to conceive of their environment in terms of (among other things) peacefulness, strength, orderliness, and potential interest-excitement. A general dimension is pleasingness. Each subject was asked to judge each of the four buildings in terms of verbal scales reflecting these conceptual dimensions.

Quite likely, some ways of simulating space are valid in terms of some evaluative dimensions and not in others; however, in this experiment only four fixed simulations and five fixed conceptual dimensions were considered with respect to four selected buildings. Otherwise the scope of this study, already highly complex, would have had to be expanded to include consideration of a wide range of dimensions in terms of which subjects can judge space.

Details of the Experiment

The experiment consisted of the evaluation of the facades of four different buildings (see Figures 2-5) on the University of British Columbia campus under four different simulations, each viewed from two positional alternatives, with each test subject using five rating scales. Generally, then, the experiment had a 4 x 4 x 2 x 5 "mixed" design (partly factorial and partly hierarchical) with buildings, simulations positional alternatives and rating scale criteria forming the four variables. Test subjects, all aged 16 or older, were recruited from passers-by attending the triennial University of British Columbia Open House. Each test subject was initially handed an instruction sheet briefly describing the project. Next, he had a "dry run" on the five different criterion scales (Figure 1), using as stimulus an architect's drawing of a proposed campus building (Figure 6). After the subject read the instructions and completed the "dry run," his responses were scanned for assurance that he understood use of the scales and was aware that any of seven scale levels could be used in responding. He then became one



ARCHITECTURAL EVALUATION PROJECT

Researchers in Architecture and Environmental Psychology are concerned with determining how the visitor to the University of British Columbia campus experiences and evaluates the various buildings on the campus complex.

A few minutes of your time will greatly assist us in planning more effectively for persons who visit the campus less frequently than faculty or students.

To familiarize you with our information collecting procedure, we would like you to examine an Architect's drawing of the Pharmacy Building Addition and to report your impressions of it on the following set of five scales.

Study the building -- then consider each scale and mark an "X" at that point which to you represents the best assessment of the building.

PEACEFUL QUIET ___ : ___ : ___ : ___ : ___ : ___ : ___ PEACEFUL QUIET
none at all slightly somewhat moderately considerably very extremely

STRONG BOLD ___ : ___ : ___ : ___ : ___ : ___ : ___ STRONG BOLD
none at all slightly somewhat moderately considerably very extremely

DYNAMIC EXCITING ___ : ___ : ___ : ___ : ___ : ___ : ___ DYNAMIC EXCITING
none at all slightly somewhat moderately considerably very extremely

ORDERLY TIDY ___ : ___ : ___ : ___ : ___ : ___ : ___ ORDERLY TIDY
none at all slightly somewhat moderately considerably very extremely

PLEASING APPEALING ___ : ___ : ___ : ___ : ___ : ___ : ___ PLEASING APPEALING
none at all slightly somewhat moderately considerably very extremely

When you have completed this sample evaluation, the project director will provide you with an Evaluation Booklet and will direct you to a viewing station at which you will assess actual campus buildings.

Thank you for your interest and cooperation!

Figure 1. The test form, showing the scales

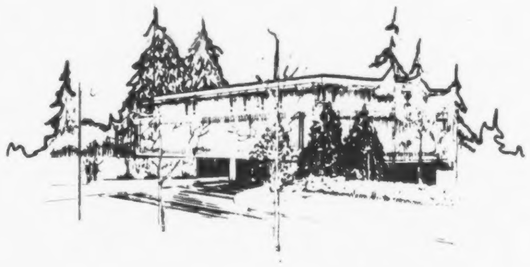


Figure 2. Graduate Student Centre

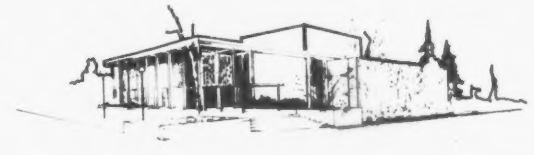


Figure 3. Frederic Wood Theatre

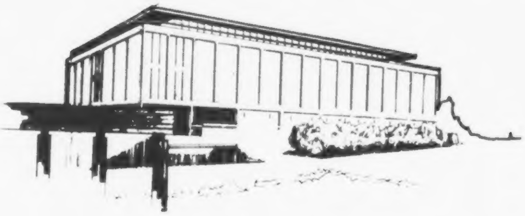


Figure 4. Lasserre Building (architecture, art and planning)

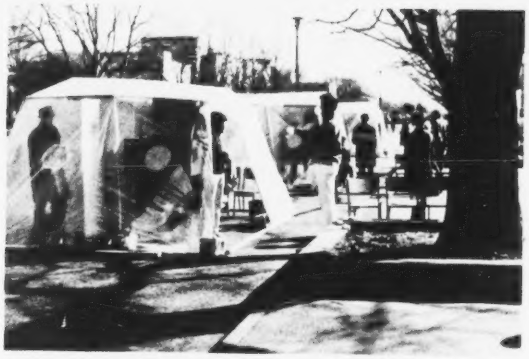


Figure 7. Tents housing models and photographs

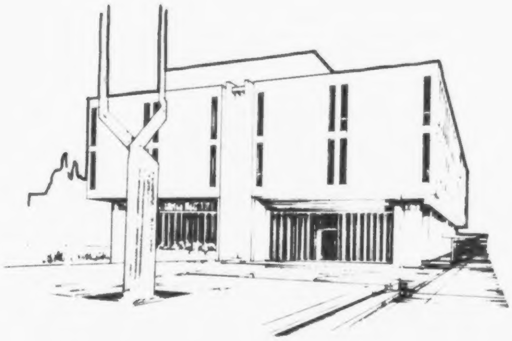


Figure 5. Music Building

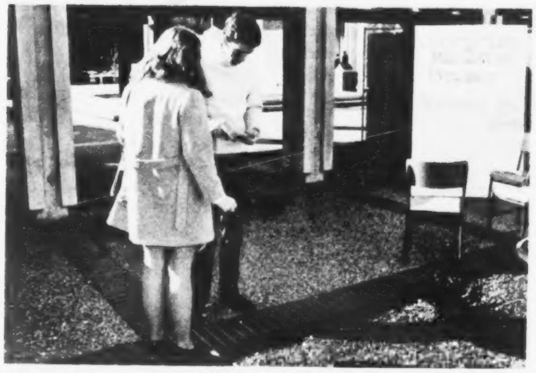


Figure 8. Model viewing tent. Note eye-level viewing tunnel on box at right

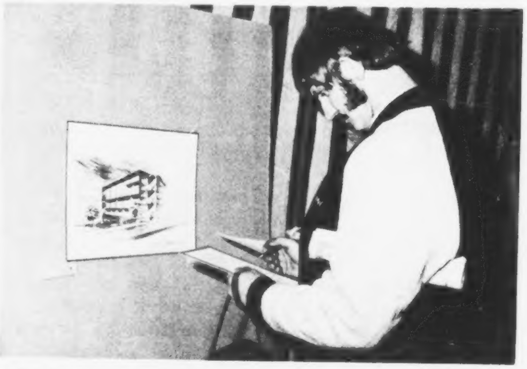


Figure 6. A "dry run" in the headquarters tent

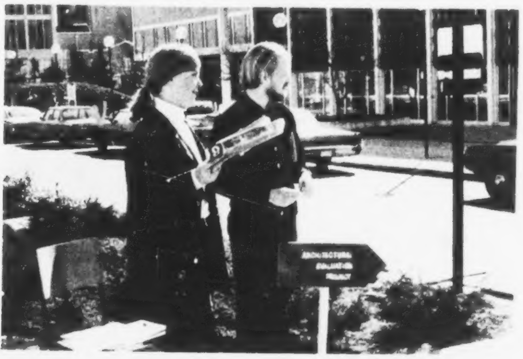


Figure 9. Outdoor substation for viewing real buildings

of 38 subjects assigned to each of eight test conditions (one vs. two viewing positions, x 4 modes of representation). He received a pack of five 5-inch by 8-inch cards, including a "cover" card and four answer cards (Figure 1). Each answer card applied to a particular building facade, identified to the test subject only by number; the sequence with which buildings were viewed by test subjects varied systematically between subjects, in eight different orders. The four answer cards (one for each building) each included five rating scales, in a fixed order throughout a subject's pack; however, different test subjects received packs in which the order of scales varied among five alternative sequences. At the bottom of each answer card was space for the subject to write in words describing each stimulus building.

After receiving his pack of cards, the subject was directed to one of four test stations at which one of the four experimental simulation modes was represented. Three stations were enclosed in translucent tents along the Main Mall of the campus (Figures 7 and 8); the fourth ("real building") simulation station was actually a pair of substations (Figure 9) from which subjects were directed to marked positions from which test buildings were to be viewed. Subjects moved from building to building (or simulation thereof) in the order shown in their pack of cards, and after completion of their task they submitted their pack of cards to a station attendant.

All this sounds very neat and orderly, but of course it wasn't at all. Outdoor experiments are full of devilish resistances and obstacles which rise to confound the experimenter. The tents housing the simulations, for example, had to be made of a reasonably light polyethylene stretched on a metallic frame. The structures were not very strong, which became manifest on the first day of Open House, characterized by drenching rains and high winds. The models and photos were saved at the last minute, before the tents collapsed. This was as well, for the models each cost several hundred dollars, being hand-made to exactly the same scale for all four buildings, using exactly the same qualities of materials and finish for each, to architectural standard. The same is true of the photographs taken by a professional architectural photographer at comparable fees. Then too, getting the subjects ordered into test groups dizzied our lives for a few days, for we had eight different arrangements of the stimuli times five arrangements of the scales times four different simulation color codes times two viewing position codes for each simulation, making a total of 320 different decks of cards to order, each replicated twice and thereafter systematically interleaved so as to achieve practical balance of sequencing and treatments. Then there were the usual personnel problems ... our dozen test monitors quit for lunch just when the big crowds came. It was a frenzied day.

A total of some 600 cases were run, but many had to be discarded due to being under age, or being students or failing to complete the full set of response cards. The latter difficulty particularly occurred in the viewing of the four real buildings, which had to be visually separated from each other and therefore had long distances between them. Time delays entailed in viewing the models, which were to be squinted at eye level through narrow slots also lead to the loss of some subjects. After screening the responses for all sources of error and omission, the least populous of the eight test subject groups held 38 cases, so other cells were pruned down randomly to this size (with some loss of reliability) so that all cells could have equal N's for reasons of computational convenience.

Results

Under the experimental design used, each test subject was put in a group (N=38) which used five scales to rate the four stimulus buildings. It would be nice if a person's twenty ratings were independent of each other, so that means and variances calculated over persons could be regarded as tantamount to independent replications of test effects. To this end, the order of looking at buildings and the ordering of dimensions judged for each building were varied systematically. However, independence of scales was not fully achieved.

Others' factor analyses of semantic studies indicated common loadings (see Table 1) on some of the scales selected for test: thus "pleasing, appealing" appears to have a factor structure relation to "exciting, dynamic", and "orderly, tidy" may share some common structure with "quiet, peaceful".

Intercorrelations among the scales are all positive and mostly of reliable order. Those of the pleasing, appealing scale with others are the highest. Noteworthy are the intercorrelations for pleasing, appealing vs. dynamic, exciting and for dynamic, exciting vs. strong, bold. Clearly there was a strong "halo" affecting raters' evaluations of buildings on supposedly independent dimensions.

On the other hand, the four test buildings did differ in their ordinal positions on different scales (see right-hand column, Table 2). Generally, the Graduate Center and the Music Building received higher marks than the other two buildings, but not on all of the scales. Also, in all but one case, the four buildings were rated lower on the "dynamic, exciting" dimension than on the other scales; this suggests a blandness or austerity of frame-and-

TABLE 3

Mean Ratings (N=38) of Buildings Varying in Representation and Position

Scale	Building	Mode of Building Representation								Mean (N=304)
		Real		Model		Color Photo		B&W Photo		
		Pos 1	Pos 2	Pos 1	Pos 2	Pos 1	Pos 2	Pos 1	Pos 2	
Pleasing, appealing	GC	4.63	4.50	4.03	4.66	4.71	4.39	4.37	4.10	4.42
	FW	4.61	4.29	3.71	4.34	4.16	4.82	3.51	3.79	4.12
	LA	3.71	3.47	4.05	3.66	3.34	3.61	4.05	4.13	3.75
	MB	4.71	4.50	4.16	4.71	4.47	4.47	3.68	3.95	4.33
	Mean	4.41	4.19	3.99	4.34	4.17	4.32	3.91	3.99	4.17
Dynamic, exciting	GC	3.39	3.71	3.76	3.50	3.40	3.45	3.24	3.32	3.47
	FW	3.97	3.63	3.45	3.42	3.50	3.74	2.97	3.29	3.50
	LA	3.05	3.26	3.24	3.13	3.03	2.97	3.58	3.34	3.20
	MB	4.84	4.26	3.63	3.84	4.08	4.42	3.82	3.87	4.10
	Mean	3.82	3.72	3.52	3.47	3.50	3.64	3.40	3.45	3.57
Orderly, tidy	GC	4.66	4.53	4.08	4.50	4.66	4.76	4.37	4.16	4.46
	FW	4.45	4.39	4.21	5.03	4.47	4.79	3.89	3.50	4.34
	LA	4.24	3.53	5.21	5.03	4.00	3.82	4.92	4.74	4.43
	MB	4.89	4.58	4.82	5.11	5.53	5.26	4.63	4.58	4.92
	Mean	4.56	4.26	4.58	4.91	4.66	4.66	4.45	4.24	4.54
Strong, bold	GC	3.45	4.13	4.76	4.00	3.84	3.84	3.89	3.68	3.83
	FW	4.34	3.71	3.97	3.58	3.92	3.89	3.71	3.39	3.82
	LA	3.82	3.66	4.18	3.58	3.68	3.32	4.63	4.05	3.86
	MB	5.37	5.24	4.37	4.16	5.05	5.13	4.55	5.08	4.87
	Mean	4.24	4.18	4.07	3.83	4.13	4.05	4.20	4.05	4.09
Peaceful, quiet	GC	5.05	4.79	4.13	4.03	4.47	4.79	4.08	4.13	4.42
	FW	3.58	3.95	3.82	4.03	3.79	3.74	3.18	3.16	3.65
	LA	3.03	3.84	4.16	3.79	3.61	3.58	3.63	3.76	3.67
	MB	3.74	3.55	3.76	3.84	4.47	3.76	3.37	3.39	3.72
	Mean	3.85	4.03	3.97	3.92	4.09	3.97	3.57	3.61	3.87

sheath architecture on the campus studied.

Validity. A key issue in this study is whether one can simulate the outside of buildings by models or photographs in order to create viewer impressions veridical with those generated by real buildings when viewed from the outside. By way of an example of our results, Table 2 gives mean ratings on the *pleasing, appealing* scale of the four stimulus buildings for each mode. On the seven-point scale (see Figure 1), an overall average of 4.17 as shown in the lower right hand corner of the *pleasing, appealing* data in Table 2 indicates that *our four test buildings impressed visitors as no more than moderately appealing*. We were glad to see that the real buildings generally rated as high (in the "mean" row) as did their double-gangers...but not much higher. We also see (along the extreme right column) that the scale discriminates clearly between the test buildings, with lower ratings allocated to FW and LA than to the other two buildings. Note, however, that this overall pattern is not replicated under different simulations; in the color photo mode, FW is a winner on the *pleasing, appealing* scale, and in the black-and-white photo mode LA rates higher than MB.

Table 2 confirms the reliability of observed variations in ratings. Because the experimental design is mixed, being partly factorial and partly hierarchical, different error terms are used to estimate the significance of different effects. The analysis confirms that the *average ratings of the different buildings do in fact differ significantly*, but that the relative pleasantness or appealingness of a building much depends on how it is represented to the public ... that is, there is a significant Building-Simulation interaction.

Note that the position variable ... with levels depending on whether a person appraised a building or model from just one viewpoint angle (or saw just one photograph), or from two ... has no main effect on the data nor any significant interaction with other variables; this was found generally to be the case across all scales.

TABLE 3

Analysis of Variance of *Pleasing, Appealing* Ratings

Source	df	MS	Error	F
Position of view	1	2.58	A	<1
Simulation mode	3	7.25	A	1.79
Pos. x Sim.	3	4.37	A	1.08
Subjects (error A)	296	4.05	B	1.76***
Buildings	3	26.84	B	11.66***
Building x Pos.	3	2.29	B	<1
Building x Sim.	9	7.20	B	3.13***
B x P x S	9	2.33	B	1.01
Subj. x Bldg. (error B)	888	2.30		
Total	1,215			

***p <.01

On all of the scales for which data are reported in Table 2, the main effect of buildings tends to emerge more strongly among the real buildings than among the simulations; on two of the five scales, the top-rated real building is scored more than a full scale point higher than its competitors. While the same pattern of differentiation also appears in the simulations, it does so much less markedly. Of the three simulations, that which seems to gain results more closely resembling those elicited by the real buildings is the color photograph mode, while ratings obtained via the models and black-and-white photos tended to blur the contrasts noted just above.

TABLE 4

Summary of Three ANOVA Tables

Scale	Average value of ratings	MS Error B	Probability of F ratios		
			Bldgs.	Bldg. x Sim.	Other
Dynamic, exciting	3.57	2.17	<.001	<.02	n.s.
Orderly, tidy	4.54	1.59	<.001	<.001	<.05*
Strong, bold	4.09	1.93	<.001	<.001	<.02**
Peaceful, quiet	3.87	1.79	<.001	<.001	n.s.

*Simulation effect
**Building x Position interaction

Data in Table 4 summarize the ANOVA tables for the four scales *dynamic, exciting*; *orderly, tidy*; *strong, bold*; and *peaceful, quiet*. On all scales both the Building main effect and

Building-Simulation interaction were highly significant, telling us both that the buildings differed reliably in terms of the scales, and that the nature of these differences varied with simulation.

To determine more exactly how the simulation modes represented reality, the means shown in Table 2 for each of the five scales in the "real" mode were used as standards against which to correlate means obtained from simulations. The two viewing positions were treated as replicates. Thus, for a given scale (e.g., *pleasing, appealing*), mean scores for both positions in the "real" mode were first ranked and then correlated by means of Goodman and Kruskal's *gamma*(5).

By this means, four correlations were generated between the two positions for "reality" and the two positions for any given simulation; over five scales, twenty *gamma* values resulted. The *gamma* values for a given pair of simulation positions were averaged (arithmetically) over all five scales. Resulting values are shown in Table 5.

TABLE 5

Mean (N=5 Scales) Gamma Values between Eight Subject Groups (N=38) Viewing Test Buildings under Alternative Representation Modes and Positions

Positions correlated	Representation Real	 Model	 Color Photo	 B&W Photo
1 vs 2	.60	.32	.73	.86
Real position 1 *vs.* simulation position 1	-	.07	.80	.00
Real position 1 *vs.* simulation position 2	-	.47	.80	.00
Real position 2 *vs.* simulation position 1	-	.17	.71	.17
Real position 2 *vs.* simulation position 2	-	.76	.51	.20

The data in Table 5, showing *gamma* correlations averaged over scales, indicates the rating data from black-and-white photographs tends to correlate highly (first row) with itself (i.e., is reliable) but has a very low positive relationship with reality. The best average performance over all scales, is provided by the color photographs, which correlated highly both with themselves and also with reality. The models seemingly do well at predicting reality only when both models and reality entail viewing a building from two distinct positions.(6)

By a somewhat analogous procedure, the 16 mean *gammas* in Table 5 were decomposed and re-averaged over scales, with results as shown in Table 6. The better average gamma performances, over all representations and positions, are those deriving from the *dynamic*, *exciting* and *strong*, *bold* scales.

Thus, taking Tables 5 and 6 in combination, it would appear that greatest degree of verisimilitude using simulations obtains when one uses color photographs to appraise boldness, excitingness or like concepts.

TABLE 6

Mean (N=16) Gamma Values between Reality and Simulation Ranks of Buildings on Five Scales

Pleasing, appealing	.30
Dynamic, exciting	.63
Orderly, tidy	.36
Strong, bold	.33
Peaceful, quiet	.42

Reliability. Eight subject groups (N=38 each) under varying viewing conditions used five scales to evaluate the test buildings. From these data, forty separate analyses of variance were generated, one for each scale in each condition. A typical example of one ANOVA is shown in Table 7. Note that the mean square error is somewhat high in this example (relative to 7-point scales generally) and inter-person error is very low (relative to most rating groups).

TABLE 7

Analysis of Variance of *Pleasing, Appealing* Ratings of Real Buildings Viewed from Position 1

Source	df	Sum of Squares	Mean Square	F
Buildings	3	25.33	8.45	3.32*
Persons	37	93.14	2.52	.99
Error	111	282.41	2.54	

$*p < .05$

The error term in the example (Table 7) is an estimate of the reliability of obtained scale values of buildings represented under a specified set of circumstances. To estimate scale reliability under varying circumstances, the forty error mean square values were extracted from the forty ANOVA and arrayed in a table showing error values for five scales, four simulations and two positions. Marginal median values for the five scales, and for the eight test groups, are shown in Table 8.

TABLE 8

Median Values of Mean Square Error Terms

Scale		Simulation and Position	
Pleasing, appealing	2.44	Real, position 1 Real, position 2	2.20 2.37
Dynamic, exciting	2.26	Model, position 1 Model, position 2	1.63 2.24
Orderly, tidy	1.56	Color Photo, pos. 1 Color Photo, pos. 2	1.89 1.80
Strong, bold	1.91	B&W Photo, position 1 B&W Photo, position 2	1.77 1.79
Peaceful, quiet	1.69		

To test the reliability of observed differences in average values, the forty mean square errors were transformed into natural logarithms; means were calculated on transformed values and related back to values in Table 8 with only trivial differences emerging. Then the transformed data were subject to analysis of variance with 39 degrees of freedom. Results are shown in Table 9. The results show a clear-cut main effect for scales. Reference to Table 8 shows lowest subject-building "error" occurring when the orderly, tidy scale is used, while relatively poor consistency obtains when the pleasing, appealing and dynamic, exciting scales are used. Seemingly our test subjects were less clear in concensus about what is pleasing or dynamic than they were about orderliness or peacefulness.

TABLE 9

Analysis of Variance of Forty Transformed Error Variances

Source	df	Sum of Squares	Mean Square	F
Scales	4	666.2	171.6	10.3***
Representations	3	163.6	54.5	3.3
S x R	12	205.2	17.1	1.0
Positions	1	1.6	1.6	0.1
S x P	4	26.7	6.7	0.4
R x P	3	205.3	68.4	4.1*
Error	12	199.1	16.6	

*p= <.05
***p= <.001

The analysis of variance of error variances (Table 9) also suggests (at about the 5% level) some reliability in observed differences in error terms between representations and positions. The data (Table 8) indicate lowest concensus among persons judging the real things rather than the simulations. (It were ever thus!) Better reliability seems to obtain for judgments of photographs, while judgments of models varied in unreliability, depending on viewing position.

A technical difficulty in building evaluations is moving judges around the country judging different structures. Things would be easier (and cheaper) if from a population of judges one group is randomly selected and sent to look at this building, another sent to look at that building, and still others randomly selected to appraise a third, fourth, etc. In such a case, comparisons between judge groups would depend for reliability estimates on variation between judges within groups.

The forty analyses of variance discussed in connection with Table 7 were first arrayed (as in Table 8) with respect to inter-subject variances, then transformed into natural logarithms and subject to analysis of variance. None of the values, which were similar relationally but not absolutely to those in Table 8 were found reliable except that (shown in Table 10) relating to an interaction between mode of building representation and viewing position. As can be seen, the interaction derives from greater inter-judge reliability obtaining from viewing two photographs while slightly lower inter-judge reliability happens when a real building or model is viewed from several angles. This interaction, significant at the .05 level, may however be artifactual.

TABLE 10

Inter-judge Variance in Eight Groups Varying in Mode of Representation and Viewing Position

Mode of Representation	Viewing Position 1	Viewing Position 2
Real	4.3	4.5
Model	4.7	5.2
Color photo	4.1	3.8
B&W photo	6.2	3.4

Power. Reliability of scales and viewing conditions is important, but the ultimate concern is for power in measurement. One measure of power, applying to type I error, is the F-ratio relating stimulus (building) variance to error variance.

To test power obtaining under the various measurement conditions appraised, F-ratios for buildings were extracted from the forty analyses of variance illustrated in Table 7. Marginal median values obtained are shown in Table 11. As we might have expected from earlier analysis of error variances, the orderly, tidy and strong, bold scales have highest power and the pleasing, appealing and dynamic, exciting scales show least discriminatory power.

TABLE 11

Median Values of F-ratios for Buildings

Scale		Simulation and Position	
Pleasing, appealing	3.4	Real, position 1	10.1
		Real, position 2	5.0
Dynamic, exciting	2.7	Model, position 1	1.3
		Model, position 2	1.6
Orderly, tidy	5.7	Color Photo, pos. 1	5.5
		Color Photo, pos. 2	7.3
Strong, bold	8.3	B&W Photo, position 1	3.7
		B&W Photo, position 2	4.1
Peaceful, quiet	4.1		

To test the reliability of observed trends, the forty F-ratios were normalized by transformation to Fisher's z(1957, p.2 and Table V), to which unity was added so that ratios lower than one would be expressed positively. The transformed values retained in large part the direction and extent of relationships shown in Table 11. These values were then subject to analysis of variance according to the procedure outlined by Anderson (1961). Results show the scale effect on power to be suggestive but not significant at low level of probability. However, the mode of representation effects appeared as quite reliable ($p < .01$). Seemingly, when viewing the models, the judges could not nearly as well distinguish between buildings in terms of the dimensions requested as when they viewed photographs or the real buildings. No other effects or interactions were found to relate reliably to power.

Summary and Discussion

The results summarized above suggest that the qualities that buildings impart to viewers are generally similar over simulations. All buildings scored relatively high on tidiness and low on excitingness, irrespective of the simulations used. On the other hand, the relative pleasingness of the Lasserre (LA) Building clearly improved in its black-and-white photographic rendering, and the same kind of observation can be made about other buildings' rankings on other dimensions in other renderings.

We were glad to observe that the Thea Koerner Graduate Students Centre (GC) rated generally quite well on the scales. This is good, for in 1962 this building won a Massey Gold Medal as a leading architectural design in Canada; had it scored poorly, the validity of our scales (or the validity of the award) would have become suspect. The Massey Medal is awarded solely on the basis of simulations ... judges do not travel about the country to view candidate structures *in vivo*. The results of the present experiment *do not* invalidate this procedure, they only make it suspect by revealing significant Building-Simulation interaction on every dimension tested.

The results of the present study do not definitively set the rules for valid use of surrogates. The seven-point scales used were somewhat arbitrary in format and content, the selection of buildings used was fixed and relatively homogeneous, the five dimensions studied were a fixed selection, and ratings on the five dimensions were performed concommitantly and therefore interdependently.

Nonetheless, the results seem to make sense. The error variances are reasonably good for scales of this length, the real buildings serve as more contrasty stimuli than their simulations, and there is a measure of agreement that some buildings are more outstanding than others on this or that dimension. The chief merit of the study is in the size of its sample of people, so that the reliability of trends can be firmly established. Also important is the *consistency* of procedures: all models were made by one artisan; all photographs were taken by a professional on a given day at a specified time; all representations were viewed from closely specified points; all subjects were run in one day, a day similar to that used for photography; all subjects were adults and strangers to the campus; all subjects were systematically spread among different treatment groups, and all test sequences were balanced between groups.

Validity, reliability and power data obtaining from the study seem at least consistent. Color photographs appear to give good representation of reality, relative to models and black-and-white photographs. The color photographs also provided good reliability and power. Viewing position (single *vs.* double angles) had little effect on the data. Among the scales, the *strong-bold* scale seemed to give good reliability and validity.

This work is, of course, only beginning. Appraisals of method are planned to extend further, to architectural renderings and photographs of models. Other students are exploring videotaping, modelscope photography and full-scale mockups. More work should be focussed on isolating the scales most pertinent to building facades. The present authors are now considering study of scaling and simulation of the interiors of proposed buildings; a set of new problems arises in these considerations.

Other studies (Peterson, Woodman, and Eaton, 1968; Lau, 1970; Holmberg *et al*, 1967; Galvin, 1970) have suggested that *generally* simulations appear to give results similar to those of reality; but of course such results can not be identical with those from reality, and the deviations between real and simulation results has not heretofore been subject to direct statistical test. The statistical tests herein all confirm that results from simulations are not congruent with those from reality, no matter what the scalar dimension, although they may be similar. These results argue for scepticism about the merit of evaluative judgment from simulations and models. We should sympathize with Leonard Fein when he remarks,

> I am dazzled, as is any layman, by the splendid models, complete to the last detail, of tomorrow's buildings. I am dazzled, but unpersuaded, for the models are the architect's, not mine. They are not mine even when he has finished explaining all their virtues and conveniences. They are not mine because their virtues and conveniences are the children of the architect's conception. They are, at best, a grafting of my groping hopes and the architectural wisdom. They are, as they are shown to me, an elaborate and compelling diagnosis, and they are, as well, an imposition. (1968, p. 198)

As Lowe (1969) remarks, today's architectural prize winners are tomorrow's fiascos and ruins, and between the conception and the creation, between the idea and the reality, remains the shadow of doubt.

Notes

*An earlier version of this paper was read at the Western Psychological Association Convention, San Francisco, April 1971.

[1] Prior to 1960, except in the housing field (see Beyer, 1965, for review of that literature), little architectural behavior research was performed (Evans, 1966) although there were many researches in the behavioral science fields...anthropology, psychology, sociology,...which had implications for environmental design (see SER, 1965, v.i.). The "state of the art" was similar to that faced by researchers two decades ago in bureaucracy and complex organization (see Selznick, 1949; Blau, 1955).

[2] Applications of this approach in social anthropology, for example, include Cohen's 1955 study of food-sharing practices or Murdock's 1949 analysis of kinship structures, both of which drew upon accumulated case studies of societies in the Yale University Human Relations Area File; for a review of comparable research in the area of formal organization, see Bass, 1965, or Blau and Scott, 1962.

[3] Examples of natural experiments appear in civil defense and disaster research literature...see Tyhurst, 1957; other well-known natural experiments are reported by Festinger, 1956 and Kerckhoff & Back, 1968. Experiments involving full-scale mockups are fewer, but can be illustrated in social psychology by the work of Sherif, 1961, and other followers of the psychologist K. Lewin; in bureaucracy by the work of the Non-Linear Systems Corporation...see Bass, 1965, pp.278-9; and in architecture in the report by Sanoff, 1965.

[4] In social psychology such experimental simulations of complex settings began after WWI and have since become almost without number (McGrath & Altman, 1966). Small scale simulations of bureaucratic structures began a decade later, for example in the work reported by the Gullahorns (1965) and the development of elaborate business games at Carnegie Institute of Technology (Cohen et al, 1964) and elsewhere; these have the merit of having been validated by correspondence with the outcomes of detailed case studies and natural experiments in the real world.

[5] Since each correlation entailed only four paired observations, use of gamma mitigated the effects of extreme values on the results.

[6] The impact of these validity data is modified by the consideration that the scales were not wholly independent, so that a high average correlation between reality and a simulation might be an artifact of the composition of the subjects in the two groups being correlated.

We are grateful to Mr. John McMaster, Office of Academic Planning, University of British Columbia, for programming the mixed-model ANOVA reported in this paper.

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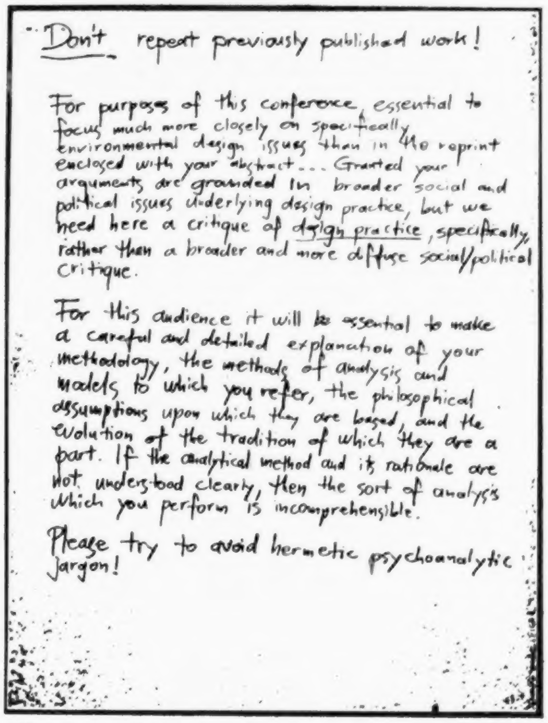
TO BE ANNOUNCED

Anthony Ward

Assistant Professor
Department of Architecture
University of California, Berkeley

Prologue

A story here
I will unfold,
about a lad
his father told
to be successful.
In conference sweet
I'll show the meat.
My poet's aim,
to show the game
by which we all are numbered.
We come
from every corner of the globe,
our nerves to test, our wits
to probe.
We chatter on
with empty sounds,
while mayhem
in the world abounds.
This lad's romance, I pray,
this tale,
give substance to
our features pale,
and bring us back
into a world
of bright significance.
For havoc reigns
where fashion grows,
experience without.
And time runs out for havoc now
as logic turns about.
We chant of logic
cold and hard,
parameters and things,
criteria and social good
the goodness science brings.
Yet myth abounds
equations' sounds.
and fantasy is rife.
While we still gaze
into the maze
we've structured
out of life.
So now perhaps the time is come
for neutral, abstract things,
the personal
is coming in
on joyous, silver wings.
So if you wish
to hear me tell
of factors such as these,
then do not waste my time, my friend.
Go! Hear the things that please.



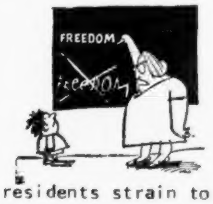
Don't repeat previously published work!

For purposes of this conference, essential to focus much more closely on specifically environmental design issues than in the reprint enclosed with your abstract... Granted your arguments are grounded in broader social and political issues underlying design practice, but we need here a critique of design practice, specifically, rather than a broader and more diffuse social/political critique.

For this audience it will be essential to make a careful and detailed explanation of your methodology, the methods of analysis and models to which you refer, the philosophical assumptions upon which they are based, and the evolution of the tradition of which they are a part. If the analytical method and its rationale are not understood clearly, then the sort of analysis which you perform is incomprehensible.

Please try to avoid hermetic psychoanalytic jargon!

Above: unsigned reviewers comment on my synopsis for a presentation at U.C.L.A. Jan.'72
Below: "Freedom" by Steadman (New Society)

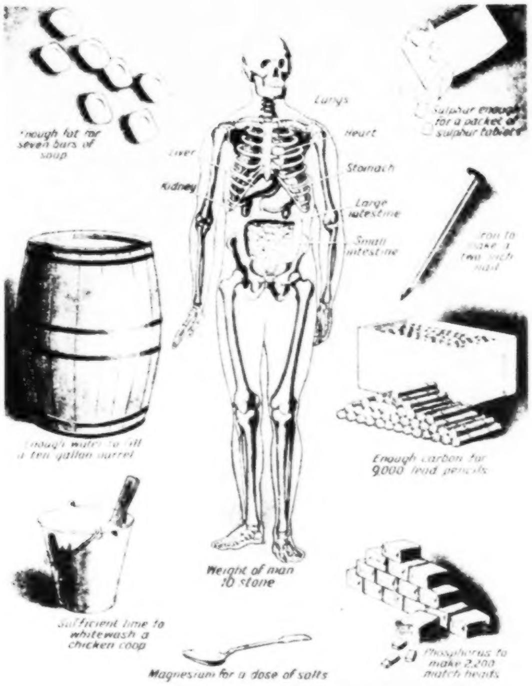


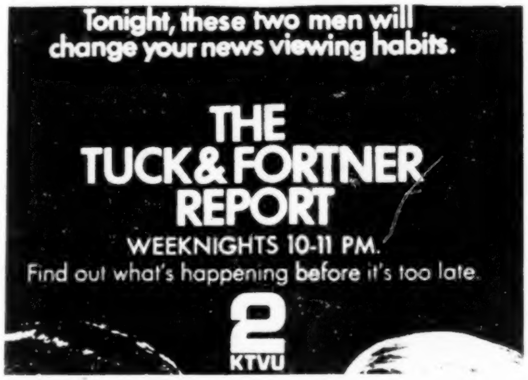
Below: Tokyo residents strain to find an inch of space where they can "freely" doodle upon a wall donated to prevent free art.

Or stay, and hear
the sweeter sounds
of music, growing steady,
as I become,
this timid boy,
the man I was already.

My story, then remains,
a lonely worker's son
amidst the Northern rains
of England.
There in that nation
locked inside my father's station,
I first began to dream
of the splendours of the moorland,
and the things my father
might have been.
I stood one day
upon a hill
and looked across the heather.
I looked upon those barbs of hell
and thought about my father.
Those blackened chimneys, there below,
his cage, his world, his pity;
and I made a promise to myself
to prosper in the City.
Out there within my discontent
in a world with all its cultures,
its brasses and its empty styles,
its mediocre vultures.
I swore that day
to make amends
for my father's sweat and trouble;
it would not end
until the day
the rich lay deep in rubble.

Do you see now, dad,
how in your hope
for a better start than you,
you made my heart both scream and grope
until my anger grew ?
You thrust your fingers
to my nose,
your callouseu hands engaging
my young, attentive, childlike eyes
til my own hands started raging;
to sculpt a hell for me and mine
to reign upon, and through
that hell to devastate
the hell that sculpted you.
Your years against a dirty world
you didn't make have ended,
in crevassed wrinkled worker's seams
your destiny intended.
Your eyes, old man, are broken too,
your shoulders bent with worry
they're testimony to your toil
and the favours you now curry.


Enough fat for seven bars of soap
Lungs
Sulphur enough for a packet of sulphur tablets
Heart
Liver
Stomach
Kidney
Large intestine
Small intestine
Iron to make 1 two inch nail
Enough water to fill a ten gallon barrel
Enough carbon for 9000 lead pencils
Weight of man 10 stone
Sufficient lime to whitewash a chicken coop
Magnesium for a dose of salts
Phosphorus to make 2,200 match heads

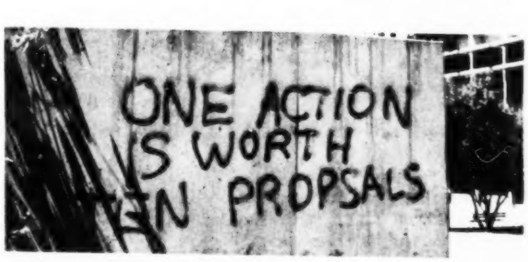

Tonight, these two men will change your news viewing habits.

THE TUCK & FORTNER REPORT

WEEKNIGHTS 10-11 PM.

Find out what's happening before it's too late.

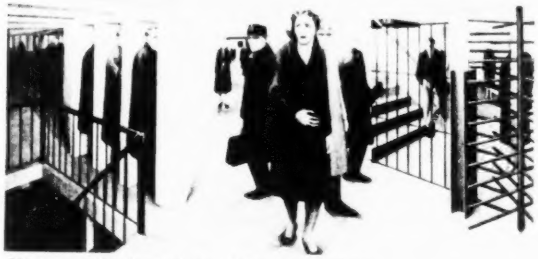
2 KTVU


ONE ACTION
IS WORTH
TEN PROPSALS

I went out then
into that world
whose guilt you almost carried,
and failing this, passed onto me
and the weaver's lass I married.
For seven years I cut and thrust.
I murdered, ate and tried,
to brutalise my colleagues trust,
to turn their love to hate with pride.
I put on the assassin's garb,
that mantle of success,
the two-faced-smile
I wore with guile.
My ambition, to be God, no less.

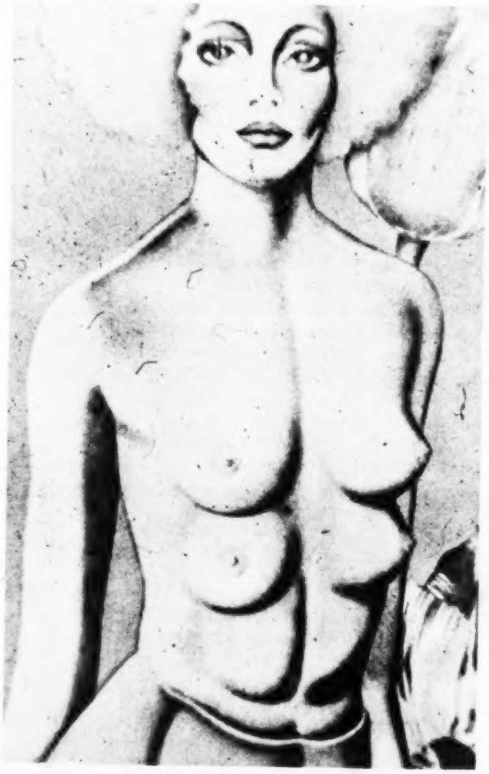
Until at last in '65
when at the top I'd stood,
that parchment which I had desired
(with my name, now etched in blood)
I carried home, proud, glorious,
the King of my small Kingdom,
and found I could not see the love
my violence was built on.
My marble eyes were cold and clear
as I came to you for blessing.
But your benediction could not hide
the love that I was missing.
My family, now, in disarray,
my wife, my son, my daughter,
so I turned about, in cold dismay
and went back to the slaughter.
I looked for loftier peaks to climb,
for greater City torment,
to London, where I hid my pride
from the present,
from the moment.
I climbed there on the bodies
of a million murdered, not by gun,
but lifeless from computer tape
in webs which I had spun.
I patterned here,
I patterned there,
with a man called Alexander.
Yet I never knew as I went on
that the pattern was my master.
I patterned in the prisons,
I patterned in the slum,
I patterned for the Government,
but my spirit would not come.
For the patterns that I spun out there,
(and for which I now had license)
were the patterns of my own despair,
designed to fill the silence.
Until at last in '68
(the year my mother died,)
a little girl with bandaged arms
sat silent while I cried.
This child, this loveless baby,
with her tender, gentle eyes,
rejected by her father's greed,
imprisoned by her mother's lies,
cast from her home, here, in a ward
of fools ad infinitum

Above: Charlie Chaplin in "Good Times"



Above: "Subway" by George Tooker

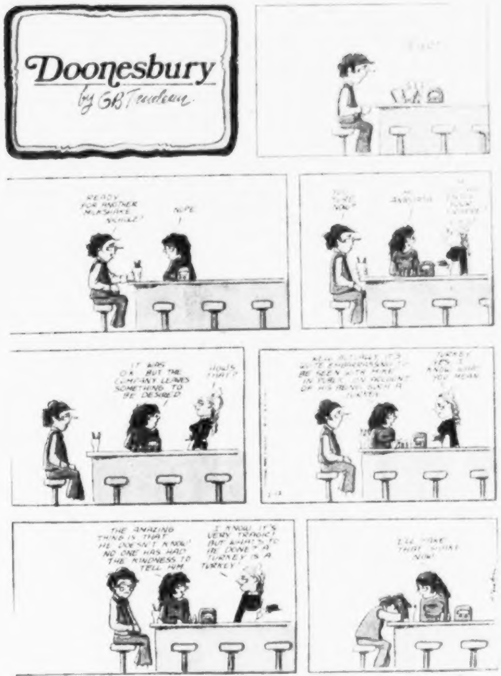
Below: A more efficient woman designed by three English gynaecologists



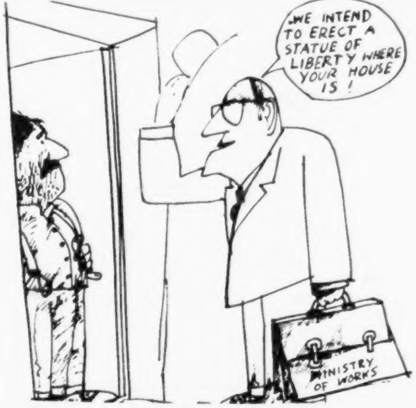
sat in her cot, the center of
a lunatic asylum---
which I had ventured to observe
for objective research matter,
not knowing that the inmates' nerve
my stone-like self would shatter.
She tried to eat her hands, you see,
for fear they would turn evil,
yet wiser eyes than mine had she
and a silence twice as civil.
Her labelled cot, a barren cage,
her eyes an invitation,
as over bloodied wrists she raged
in muted condemnation.

Take me, take me little girl
to the seat of my despair,
where criteria are cobwebbed
and parameters are bare.
And in some distant program,
I pray thee take my hand,
and guide me to that madhouse
which is the promised land.
O guide me, guide me, guide me,
for I fear that all is lost,
if I cannot find the well-spring
of my personal disgust.
I look on you, my comrades,
you lunatics and queers,
you prisoners of my problem,
you sumps of culture's dreadful fears.
And I see in you my model
as I see you through the screens
of my very own intestines,
of my many might-have-beens.

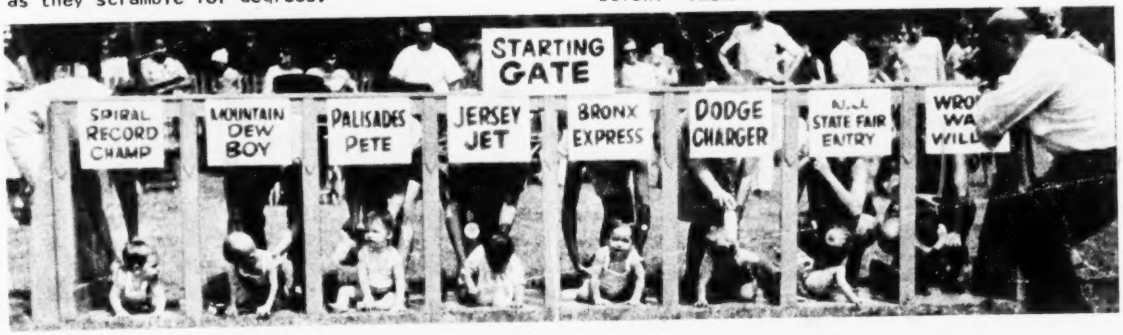
She took me down, into her eyes,
to a world where good is bane,
where the world is schizophrenic
and the lunatics are sane.
She held my hand and showed me
our culture's pride and joys,
and I saw in them the essence
of my loveless, cruel ploys.
She showed me little babies
competing on their knees,
and I thought about my students
as they scramble for degrees.


Doonesbury
by GB Trudeau
READY FOR ANOTHER MILKSHAKE, NICOLE?
NOPE!
IT WAS O.K. BUT THE COMPANY LEAVES SOMETHING TO BE DESIRED!
HOWS THAT?
THE AMAZING THING IS THAT HE DOESN'T KNOW! NO ONE HAS HAD THE KINDNESS TO TELL HIM.
I KNOW. IT'S VERY TRAGIC! BUT WHAT'S TO BE DONE? A TURKEY IS A TURKEY!

Above: Normal Behaviour ? (S.F. Examiner)
Below: Steadman on Liberty

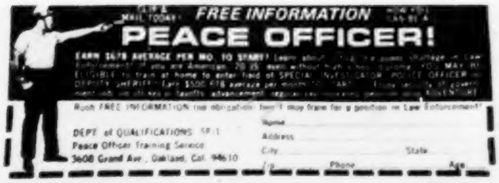

WE INTEND TO ERECT A STATUE OF LIBERTY WHERE YOUR HOUSE IS!
MINISTRY OF WORKS

Below: The Baby Derby


STARTING GATE
SPIRAL RECORD CHAMP
MOUNTAIN DEW BOY
PALISADES PETE
JERSEY JET
BRONX EXPRESS
DODGE CHARGER
N.J. STATE FAIR ENTRY

She took me to the cathode tube
and showed me how a gun,
when wielded by 'peace officers'
is an implement of fun.
She took me to the Senate
where men there talk of peace,
as they vulgarise the language
and sell this planet's lease.
To those who can afford to buy
an island, peace and quiet---
while the sewage from their profits high
is to others, staple diet.
We heard talk of Ecology
from politicians sweet,
as they defoliate the World
outside their stately conference seat.
We looked upon the magazines
that talk about events,
and we read that we could change them all,
if we'd merely sit content.
She took me to my college
where Education's free,
and she pointed at the tear-gas
and the old and poor you never see.
We looked down on the programs
that they run there in the schools,
devoid of all morality
to manufacture android fools
who have the skills to change the world
but not the inclination,
who see the world through eyes not wise
but crammed with information.

And so at last we came to halt
in Architecture fair,
and I stared to see the monstrous fault
I'd propagated there.
I saw a typist whom I'd made
and essence of her speed,
and I saw her fingers change to keys
and the tabulator bleed.
For her problem is not motion,
nor merely typing speed,
but the feeling of emotion
which is her constant need,
denied to her by all who act
as if she were an object,
amongst a million others
in this alienating project.
I saw, then, three old people
in Roehampton die of grief,
as they could not reach the Winter's fuel
designed for their relief.
And I realised the guilt I'd hid,
the truth I'd tried to gild,
the anguish that I'd caused out there
in my desire to build.
I saw the prisons I'd designed
the dungeons manufactured,
and I pondered on my motives
as I looked upon the pain,
and accepted all the torture
as my damned-up tears began to rain.



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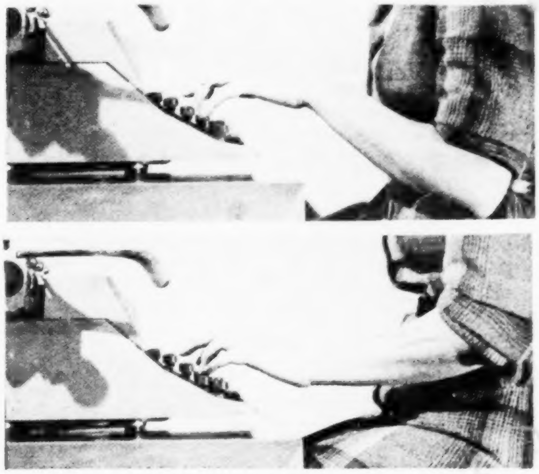
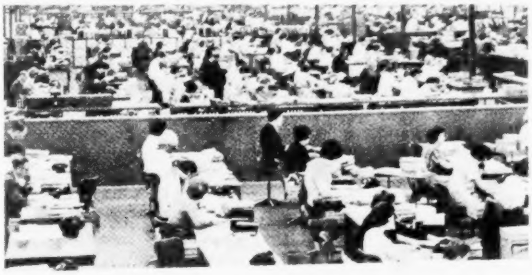
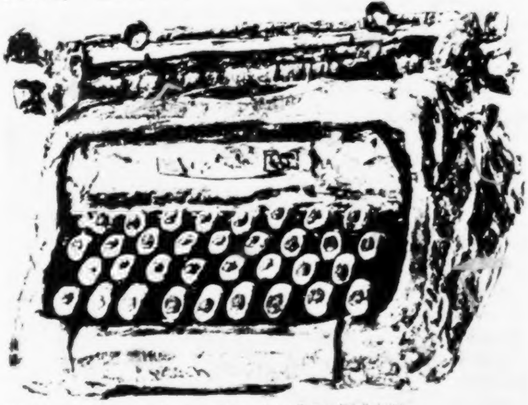


Above: A typist works faster in comfort.



Above: Comfort ?

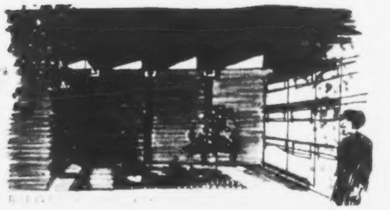


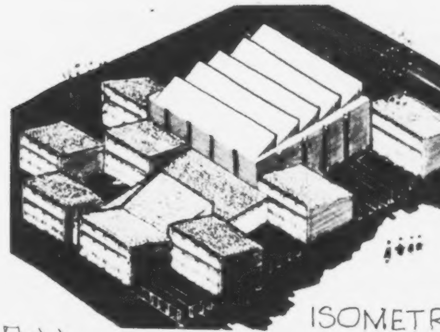
Typewriter, by Robert Arneson. Permission of University Art Museum, U.C. Berkeley

I knew then that all my 'mistakes'
were not mistakes at all,
but the doings of my own intent
to cover up the gall;
that I now felt come thrusting out
in waves of pain and sorrow.
So I made another promise,
for today now,
not tomorrow.

All this I saw in high relief
before my vision ended,
and I left my little guide alone
my former breach now mended.
I lay down catatonic, my body wracked with pain,
and then arose,
and to compose,
I then began to work again.
My words now had a different aim,
my phrases full of passion,
my lines began to live again,
transcending whim and fashion.
And when I'd done
and looked upon my work
with introspection,
I found that it was written by
an unknown man, his mothers son,
for whom I felt affection.

I looked then at an old design,
a school for juveniles,
from wealthier homes by far than mine,
from the Middle class I'd so defined,
and utterly reviled.
This private school for bankers sons
I'd found so satisfactory,
I realised was not a school,
but was instead a factory;
that I'd designed to persecute
enscapsulate and limit,
to propagate my father's cell,
subject these infants to his hell
and the violence within it.
Yet more than just a weaver's roof
was captured in my drawing.
In each design I saw a thread,
the landscape of my biggest dread,
the graveyard of my conscience dead,
my Northern town, the streets, the shed
which housed the looms the weavers fed,
which kept the profits flowing.
My program, then, was not as told,
but dreams of my salvation;
that I'd transmuted into gold
from the lead of my creation,
to free myself from forces old
to interject a spanner
into the works which kept me down,
since childhood, in the manner
the Middle Classes have who frown
upon the workers banner.
My paradox was huge yet small,
reflecting, now, belated.





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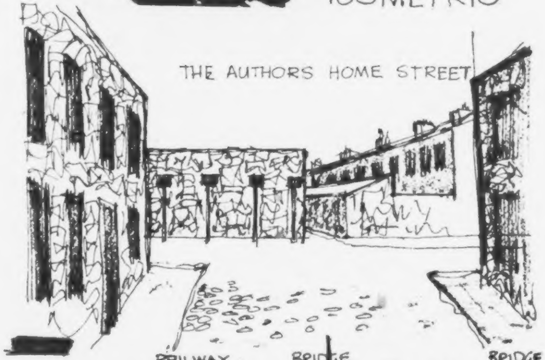
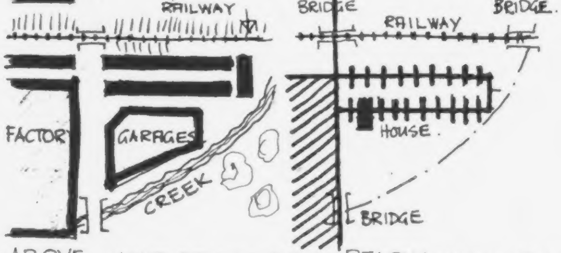
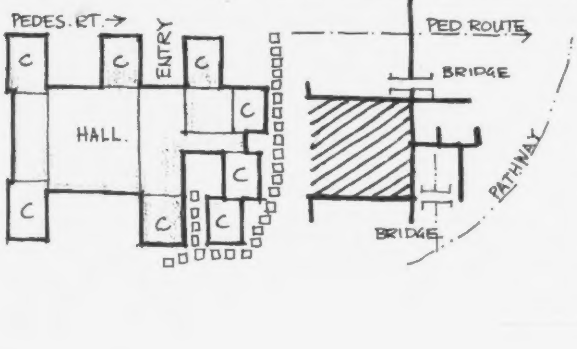
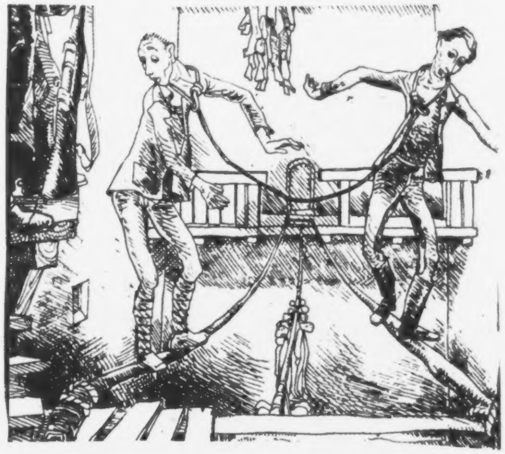




ABOVE – HOME STREET PLAN BELOW – SCHOOL PLAN.

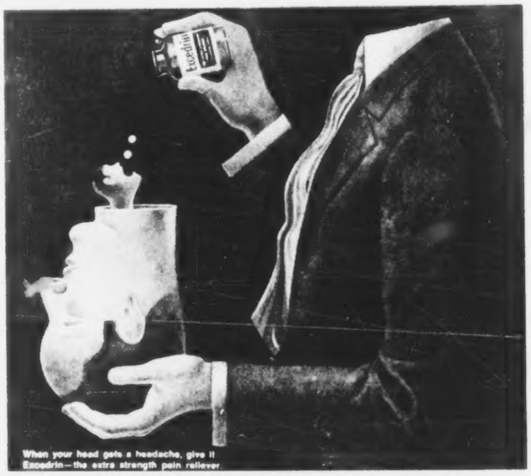


I was not Working Class at all,
nor the Middle Class I'd hated,
My tone, alone, was Middle Class
though my words still grim and racous,
but I never was allowed to pass
into that fancy caucus.
A displaced person I'd become,
entirely out of focus.
I could venture to my past,
my future too, was bolted fast,
the present empty, overcast,
a self without a locus.
Armed with this sentiment I found
in some recess of my being
a myth I'd built, so whole, so round,
preventing me from seeing that
ny hate was for myself, no less,
for having loved a mother
who hated me enough to bless
my hating of another.

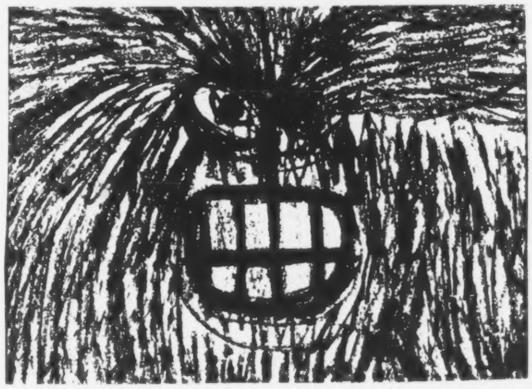


Above: Drawing by Schizophrenic. "The Divided Self ?"

The histories of Freud and Jung,
the whole Vienna Circle,
of Wilhelm Reich and Adler
and every young disciple
show clearly how the mind's a song
of many complex vowels,
of many cadences, that lead
back down into the bowels
of a memory of childhood,
of things almost forgotten,
but still forgetting to forget,
we turn this planet rotten.
Yet Planners pay no heed to this,
as if it were invalid,
they ply their skills so full of greed
until the self turns pallid.
It seems so clear to me now,
that a body without love
has the outside of a giant,
but the inside of a dwarf;
who will be free,
who will have air,
despite his keepers wiles,
but who murders, rapes and pillages
while the giant only smiles.
Each person has a private beast,
the root of his damnation,
who when accepted will release
immediate salvation.
For a giant's but a cringing dwarf,
whose substance, paper thin,
is founded out in other's selves
instead of founded deep within.
And a dwarf is but a giant,
who's manacled and beat,
who rages on the inside
of his outside counterfeit.
Our science, our technology,
our objective loveless ways,
are built to help the giant smile,
to keep the dwarf in chains.
But his fetters are the reason

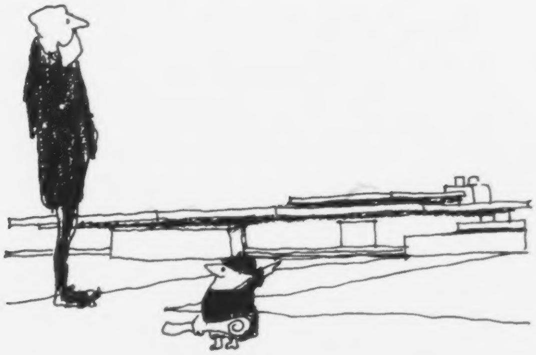

Excedrin
When your head gets a headache, give it
Excedrin—the extra strength pain reliever

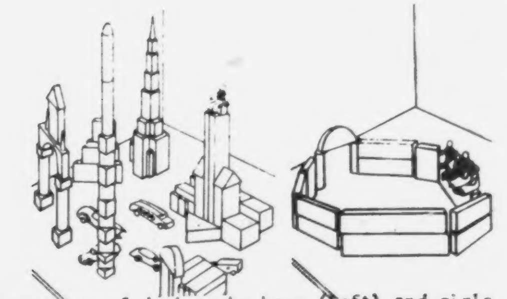
Above: An Excedrin ad. "Feed your head"
Below: Drawing by a Hebephrenic child.



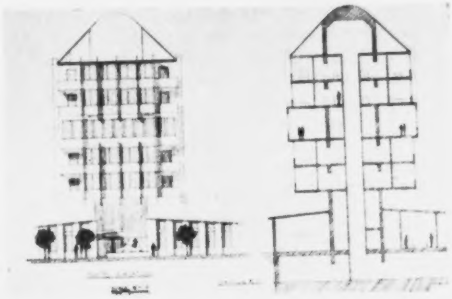
for his very brutal ire,
and if set free, will liberate
the giant's first desire.
Once reunited with his shell,
this animal is rich
in mystical creative work
the separation keeps from reach.
Each needs the other for his joy,
each keeps his friend in pain;
as each conspires to pervert love,
the love they pervert
perverts them.
When a pigmy for a giant builds
he needs no information;
he has experience of those
who've kept him in his station,
and so will build a dwarfish house,
to house his bigger client,
reducing him to just his size,
for all good will, defiant.
Nor computer program, neither brief
will alter his intention,
for his body is his data bank,
which the programs never mention.

For Erikson has shown us how
designs contain invective:
the things we build and most avow
are fantasies wherein we sow
our personal perspective,
our body-image real and true,
in graphic form effective.
Some draw a penis, some a head,
some build a wholesome figure.
Some represent themselves as dead,
or make themselves minute instead
of seeing themselves bigger.
For the tensions that a body sees
when it views a situation
are the outcome of the body's deeds,
the forces of its unmet needs,
the sustenance on which it feeds,
projected in a way that heeds
no other explanation.
Each person finds his anguish there
in concrete connotation;
his fears, his hopes, himself laid bare,
his whole preoccupation.
For the form reveals the total man
in splendid isolation;
the gestalt of his conscience's span,
the substance of his inner plan,
his image of his friends and clan,
his ego whether strong or wan,
an integrated self, or one
in total fragmentation.
For the self that we display therein
is the self we mostly hide,
the inner dwarf who will not let
his giant self abide.
This split between the inside
and the outside of a person
is the product of our loveless times,

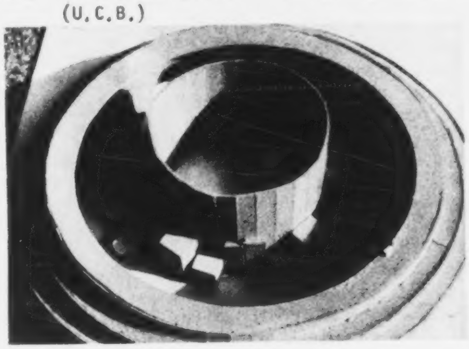




Examples of designs by boys (left) and girls (right) (Erikson)



Above: Student Housing project by a young man (U.C.B.)
Below: Laundramat project by a young woman (U.C.B.)

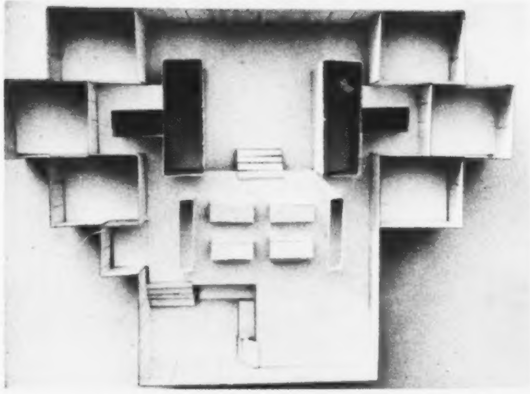


our research and out telex lines,
our questionnaire that so defines,
our social game that just reminds us
that we're less than human,
and breaks our hearts, and starves our minds,
and leaves us merely shells behind
which once were man and woman.

Epilogue

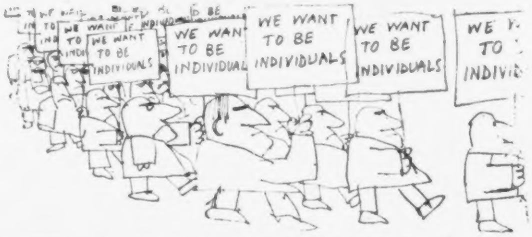
This poem, then has for its aim
to tell the situation
that brought me to myself again,
in tune with my creation.
I do not laugh at you, my friend;
that is the inspiration
of fools, who caterwaul and state
and point the finger everywhere
instead of at the truth, laid bare---
themselves in all their dark despair
their own disintegration
omitting all this from their books
of sordid information

Each person chooses where to stand
and laughs at all his brothers;
yet the place he chooses is the one
most laughed upon by others.
And so each person is the same
identical and empty
reduced to mere compartments of
himself in all his plenty.
Each chooses to avoid himself,
and look instead at others;
and the others whom he looks upon,
he alienates and smothers.
Yet if he would include himself
within his own equation
the world would be a richer place
more worthy God's creation.



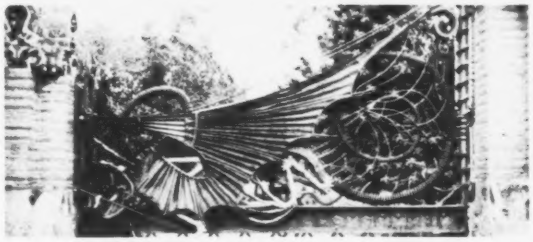
Above: Anthropomorphic housing project by a young woman (U.C.B.)

Above: The hippies watch the cops watch Krishnas


WE WANT TO BE INDIVIDUALS
WE WANT TO BE INDIVIDUALS
WE WANT TO BE INDIVIDUALS
WE WANT TO BE INDIVIDUALS
WE WANT TO BE INDIVIDUALS

Above: INDIVIDUALS, FREE ? by Steadman(New Soc.)

Below Right: Dragon Gate by Gaudi, who must have experienced himself very differently than the designer of the M.I.T. building (below left)



PLANNING, DESIGN AND BLACK COMMUNITY STYLE: THE PROBLEM OF OCCASION-ADEQUATE SPACE

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Introduction

While many disagree on the exact nature of black community life, there is wide agreement that black sensibilities and community life particularly at working class levels and below, differ significantly from those of most other racial and ethnically distinguishable groups in the United States. Much has been made of this point for political purposes, but there has also been some recent thought, largely stimulated by urban-ethnographic studies, (1) that such differences may have implications for the miniscule as well as large scale aspects of environmental design for black people.

I propose here to explore one distinctive feature of black community life which may ultimately be suggestive of ways in which the character of such communities can be taken into account in the design directives of city planners, architectural programmers, and others actually or potentially associated with the construction of black peoples' built environment (2).

The general need for studies which inter-relate the social and physical environments from the perspective of potential application has been recognized (3). The discussion of that connection has become enormously popular in recent years, but has mainly been the prerogative of those who have the prospects and can afford to buy the time and talent to build to suit their "life styles." For the poor there was until recently a continuing and increasingly radical disjunction between the buyer (often the Federal government), the builder, (architects and developers) and the users (the poor themselves). The corresponding increase in social distance was accompanied by a dramatic incongruence between the values and expectations of those buying, building and using.

In relation to black people in particular there has been occasional casual, startled, and even angry recognition of those value differences and their implications for design. As the recognition of these facts has increased so have calls for action. Joseph Black's comments represent a response to the particular needs of black people.

> Very little documentation exists on the character of the black community as a basis for planning. . . . Nobody has carefully analyzed the attitudes of black men concerning open space--analyzing, for example, how streets of the ghetto serve as living rooms of the community. Design formulas created in graphics studios and computer studios will help little to stimulate social interaction, economic integration, and political progress unless one adds the ingredients of intuition and respect for the life style and requirements of people from different cultural backgrounds.(4)

The new recognition is important, but the difficulties of effectively acting on such recommendations resides in the fact that design information is not grounded in any detailed theory of human association. While there has been a great deal of folkloristic sociological pronouncement by some architects speaking ex cathedra as master form givers, their notions remain untested, untestable, and unrelated to any experience other than that of the architect (5).

There is a well established heritage in architecture which supports this aesthetically based sociology and psychologizing. While there once may have been an assumable congruence between the architect or planner and his client, the interpenetration of neither desired images in built forms nor images of the living conducted in and around them can be assumed between today's user and the designer.

The following discussion, then, is the beginning of a broader conceptual and research program, taking the problem posed by Black, to pull the insights of sociology and the issues of design theory and practice into some form of alliance. Drawing from arguments in the symbolic interactionist literature in sociology (6), case examples from recent urban ethnographies, and generalizations from my own field experience (7), I want to develop a way of looking at mundane urban life to render certain social-organizational patterns problematic in a way potentially useful to design researchers and, ultimately, practitioners and planners. Much of what I'll discuss can be and has been dealt with in ordinary prose by others including architects. It is my belief, however, that a fine conceptual net which encompasses a large reality relevant to design is better for practice than ad hoc observation.

More specifically, the discussion is intended to guide the architect's attention to social phenomena potentially relevant to programming; to help develop programming through systematic attention to certain elements of social organization of actual and potential users of the built environment. Programming is the intersection of social studies and design at which useful results are likely to appear, but the variety of research findings, conceptual schema, etc., which are available in social studies must be approached primarily as aids to problem perception rather than as pieces for the construction of a theoretical structure.

The intent of this paper, then, is practical, to help programmers see, not to have designers take--chameleon-like--the shape of the client or user in their solutions. While proposing a way to look I will say little here about what to do with what is seen. The latter is most important, of course, but the first item on the agenda is refocusing programming (8). In that connection, I would like briefly to discuss some problems on the agenda of the burgeoning field of environment and behavior studies.

The field is, I believe, plagued at present with the twin tyrannies of premature precision in measurement and premature attempts to establish point-for-point articulation between the physical and the social-behavioral. In the former instance there seems to be in this young field an overweening concern with verification. This is most peculiar. Since our central subject matter is interstitial to some inexact sciences and changing practice, one would think that the "logic" of discovery would count for more at this early stage than the logic of verification. Perhaps one explanation for this emphasis is some felt need on the part of investigators interstitial to established disciplines and practices to defend themselves against the fad-like character of current "environmental" enthusiasms. And, while the concern may also be to weed out rank speculation early in the history of the developing field, it would appear certain that "a loose speculative approach to a fundamental field is better than a rigorous blindness to it" (9). We stand in danger of winding up "unscientific" only if we insist prematurely upon applying exact measures, disciplinary conventions and canons of evidence to inexact problems. We're really in no hurry, and we won't be saving science or society from any real or imagined barbarians, even if we rush!

The second tyranny involves our peculiar problem of having to map, simultaneously, into social and physical reality. Design research must develop an integrated set of concepts which bridge concerns of the physical and the social. It is inadequate simply to juxtapose words from both areas of investigation in the hope that they will achieve some meaning peculiar to design. The area label "Environmental Psychology" is often misused in this fashion. For the generation of usable research findings the task is deeper than that.

When an architect speaks of walls he speaks of structure, mass, form, texture, etc., or materials such as brick, concrete, steel, and the like. After dealing with certain stress features of the materials and the wall, his aesthetic concerns may come into play. To a sociologist, any interest in walls is likely to concern what activities and people they include, exclude, represent, and so forth. Not that the architect isn't similarly concerned, but his interests ordinarily do not take the discipline-based focus of understanding how the walls of a home, asylum, or an office tie persons, roles, statuses, together in a relatively coherent social organization.

Many will, of course, argue that a good architect does do the latter and that that analysis is reflected in any good program, if not in a sociological tract. This is arguable, but the central issue here is that the simple summary concept "wall" can mean very different things to the sociologist and the architect. The nouns (popular concepts) of ordinary language can route the thinking of two competent speakers of that language in opposite directions determined by the context to which they attach their meaning.

A community of design researchers needs an integrated set of concepts and conventions which point to and describe a reality of peculiar interest to it. Concepts like Robert Sommer's "personal space" or Roger Barker's "behavior setting" are compelling to design researchers and designers not simply because, as concepts, they bridge social and physical concerns by including a physical and human component in them, but because they have described, through research, a portion of the phenomenal world of potential use to the architect, and they also provide tools for the conduct of research in greater depth.

"Ecological psychology," (10) for example, had to await development of a set of highly articulated and competitive orientations to psychological man before it could grow, as it were, in the cracks between them. But our problem is more severe in that the "field" stands squarely in the midst of traditional concerns with practice on the part of design professionals cum researchers, researchers now excited with the possibilities of application, and researchers who come from differently focused, if not competing, behavioral studies. The problem of developing bridging concepts is compounded by this fact.

One task which must be undertaken, then, is the vigorous exploration of theories and concepts extant in social and behavioral studies and the selection from among them of what appears promising for productive application to problems of the built environment. There is, I believe, a tremendous amount there which will prove to be irrelevant to those concerns. As I have indicated, although my interest is ultimately practical, the orientation of the discussion which follows is toward a comprehensive view of certain social activities--social occasions--distinctively effected and bounded in physical space. "Social occasions" is not exactly a bridging concept in itself, but points to elements of social organization based in and in large measure dependent on the physical. It deals with acts which bring gatherings together in spatial situations. This article explores that connection. Still to be undertaken is the exploration of possible ways in which designed physical arrangements might or might not accommodate the social-occasional style of varied people. The people toward whom this discussion is practically aimed are the black poor in urban communities and neighborhoods. They are taken here to be stylistically distinctive in the ways in which they occupy and use the spaces they inherit or that are built for their occupancy.

Social Occasions

Human social existence is, among other things, about the purposeful, periodic and, usually, regular coming together of people for the satisfaction of various individual and social ends. Such gatherings are the subject matter of disciplined attempts to understand the nature of orderly human existence. The sociology of Erving Goffman constitutes an approach to such gatherings which has great potential utility for clarifying social issues related to the built environment, its planning and design.

Casually in *Encounters* and with more precise detail later in *Behavior in Public Places*, Goffman develops the concept of "social occasion." Recognizing, I suspect, the interpretive potential of the concept, he goes beyond roughly equating it with his "focused gatherings" and "situated activity systems" as he had done in the earlier work and discovers for it a relatively clear definition:

> When persons come into each other's immediate presence they tend to do so as participants of what I shall call a social *occasion*. This is a wider social affair, undertaking, or event, bounded in regard to place and time and typically facilitated by fixed equipment; a social occasion provides the structuring social context in which many situations and their gatherings are likely to form, dissolve, and re-form, while a pattern of conduct tends to be recognized as the appropriate and (often) official or intended one--'standing behavior pattern,' to use Barker's term. Examples of social occasions are a social party, a workday in an office, a picnic, or a night at the opera (11).

Since many in design research are familiar with Barker's concept of "behavior setting," it may be efficient to clarify Goffman's concept by contrast. Briefly, "situation" in the above definition is the "full spatial environment anywhere within which an entering person becomes a member of the gathering that is (or does become) present" (12). "Situation" is, then, generally equivalent to Barker's "milieu" containing when relevant, for example, the fixed equipment facilitating the occasion. The consistent relationship between a type of conduct and a situation is what Barker calls a "standing behavior pattern" (13). But social occasions differ from behavior settings in that inter-subjective meaning among the participants is critical to the former and tangential to the latter (14). The meaning of the inter-action in ongoing occasions is crucial to participants (and to observers). To comprehend the action one must know "what's going on" in the participants' terms.

This latter difference between the two concepts is further demonstrated in Goffman's notion of "social order" upon which the concept of social occasion is predicated. A social order is

> the consequence of any set of moral norms that regulates the *way* in which persons pursue objectives. The set of norms does not specify the objectives the participants are to seek, nor the pattern formed by and through the coordination or integration of these ends, *but merely the modes of seeking them*. (15)

Barker, in his work by contrast, is not concerned with moral norms regulating the legitimate modes of seeking objectives but with the consequences of consistently located assemblies of "molar" behavior and milieu forming an integrated whole in time and space (16).

Social occasions are, then, like behavior settings specifically located in time and space, but, whereas the properly social character of symbolic communication defines occasions, it is an epiphenomenal feature of behavior settings.

Goffman's primary concern is with the regulated content of social occasions; the interactive dynamics of what he calls "face work" and the "situational properties" (17) of occasions as ongoing process. He is concerned with the kind of regulation which "governs a person's handling of himself and others during, and by virtue of, his immediate physical presence among them. . . ." (18) But there are at least two ways in which the presence to each other of gathered people can be regulated, and, in adapting and extending Goffman's productive concept, I will want to concentrate on one: First, there are rules which govern the interactive content of occasions, that is, how the rules of a social order instruct the people co-present in an occasion to be with each other once they are gathered. These rules are about interpersonal detail and style of communication among those at church,a party, a funeral, at work, etc. Secondly, but prior in the timing of occasions, there is a related set of regulations governing the forming up of the people and situations in which such interaction takes place, rules, in other words, which govern the construction of the "arena" or "shell"--both social and physical--of social occasions.

Aside from the face-to-face aspects of orderly co-presence in social occasions, then, there is the additional dynamic of bringing about, locating and completing them in time and space. Depending on the occasion, action on behalf of these regulations may or may not be the province of single persons, but they are, in any case, always analytically separable as acts. In one case a formal meeting may be called by a secretary, managed by a chairman, controlled by a sergeant-at-arms (the case of some union meetings, for example), in another the host of a social party may be assumed responsible for all these forming up tasks.

What is terribly interesting to me in this is the possibility of applying an understanding of acts effecting the emergence of social occasions--occasioning acts--to the problem of analyzing and understanding the users of various spaces and places for which plans and design programs must be developed. My interest therefore, is in the ways in which social occasions are caused to emerge, are located and defined by the various individual and group members of organizations, neighborhoods, homes, offices, and the like; how, again, the "shell" of social occasion structure is established in time and space. Answers to these questions asked of various users of the built environment will, I believe, carry important information for the construction of the physical "shell" within which their social-occasional life can best be accommodated.

Occasioning Acts

A preliminary and extremely suggestive effort to develop a typology of social occasion-effecting acts has been conducted by Howard Boughey. Indeed, it is his work which has, I believe, extended Goffman's in such a way as to make it particularly relevant to problems of social analysis for design. Boughey's recent work is in fact the result of his earlier attempts to make social and sociological sense of architect-designed spaces and the intentions of architects to affect behavior in them (19).

In "Time, Space, Occasion: An Analytic Scheme for the Study of Timing and Spacing Acts," he inquires after those acts which render spaces "occasion-adequate." He posits

> One way to open our eyes to the concrete realities of time and space as they are construed by participants in social interaction is to ask the question, how do occasions of social interaction get occasioned, that is, what is the work of participants necessary and sufficient to establish and maintain an occasion as what it is in time and space?(20)

He presents two sets of acts which create what he calls the Elements of Occasion-Adequate Space and Occasion-Adequate Time. For purposes of this discussion I will consult only the former.

Boughey has extracted from many examples of spacing acts a categorical scheme of act types which in effect construct the socio-spatial arrangements of whole social occasions. Space limitations, unfortunately, will not permit a detailed or extended discussion of the scheme as presented here nor in my application of some of its elements to patterns of occasioning the black urban poor. But it is necessary and instructive, nonetheless, to reproduce the types here in outline. I have done so below, retaining, where possible in brief form, Boughey's explanatory terms (21).

Elements of Occasion-Adequate Space

1. Acts of SPATIAL DESIGNATION:(naming, labelling and locating the place at which the occasion shall occur). Designation is that process which ends in the establishment for participants in a social occasion of a 'where' for that occasion to take place. The meaning of that 'where' for participants may be inherent in the spatially designated locale or in the name given an occasion in the designatory act. Such acts may perform any or all of the following functions:

a) Location: Mapping an occasion into litteral spatial reality.

b) Inclusion: Enclosing all relevant participants in an occasion within a system of adequately shared meanings as to the relationship between its name or label and the physical place.

c) Intimation: Instructing occasion participants (and sometimes those specifically excluded) as to the nature of the intended occasion.

d) Binding: "Synonymizing" locale and occasion. "Inhering" occasion features in its spatial designation and vice versa.

2. Acts of SPATIAL CONVENIENCE: (taking a route; 'arriving' and 'entering': gathering; indicating and acknowledging 'presence'; the establishment of a 'here', and the converse of gathering, dispersal). All acts adding up at some point to the convening of occasion participants. They may perform any or all of the following functions:

a) Gathering participants physically into the spatial grouping required for the activities of the occasion.

b) Identifying boundaries of co-presence for the course of the occasion.

c) Spatial positioning of each participant to include or exclude him from occasional interaction at any moment.

d) Establishing mode of occasion co-presence. Degree of formality. Degree of intimacy.

e) Establishing mode of individual presence. Appropriate mode of individual participation. Legitimacy of individual presence. Requiredness of individual presence.

f) Dispersing acts reverse the occasional process

3. Acts of SPATIAL PROVENIENCE: (22) ('hosting' and 'guesting'; asserting jurisdiction; controlling access; maintaining boundaries; the establishment of 'whose place'). The occasion-space, having been made the possible site for the occasion by adequate designation and further constituted as the appropriate interaction-space by convening acts, acts of provenience assert control, jurisdiction and territorial domination over the occasion-space. These may perform any or all of the following functions:

a) Legitimating the boundaries of the occasion-space.

b) Attaching specific rules of behavior to the space.

c) Protecting the identity of the occasion-space against possible incursions over the course of the occasion.

Boughey discusses a final residual category of acts he calls "spatial interaction." I shall not include it here since it deals with the regulated content of social occasions, "('face work'; using personal space; appropriate moving and self-placement; space rituals)," which take place after an occasion-space has been made adequate through naming, locating, convening and provening.

Spaces are, then, made occasion-adequate by bringing the site into occasion-possibility through designation, rendering it occasion-appropriate through convenience, and the participants and activities dominative over the site throughout the duration of the occasion. In lieu of proliferating examples of each act at this point, I will procede to a discussion of some examples of occasioning in some black urban poor settings. The reader should refer to Boughey's fuller exemplary discussion of his scheme on both timing and spacing acts (23).

It must suffice here to point out that he does not suggest that occasioning acts are exclusively the performance of individuals or groups at the time of an occasion. "Employees only!", "Board Room - Keep Out!", "Dining room," and other signs for public instruction and direction he takes as acts as he does generally designatory symbolic objects and statements "marking" the spatial arena appropriate for certain occasions. But these acts are operative in real time and language ("back to work!") and roles (chairman, host, sergeant, maitre d'hotel) are equally the province of occasioning acts. These latter constitute the primary focus of this paper.

Occasioning: Distinctive Forms of the Urban Poor

Since I propose to apply some of the ideas developed thus far to an understanding of the spatial behavior of poor people and poor black people in particular, a few words are in order about race and poverty. First, while I am taking race to be important for the topic under discussion, race, except as an historically determined canalizer of experience, is unimportant. It should be clear at the outset that I am not suggesting anything as stupid as genetically determined relations between social and spatial variables. Secondly, poverty is evil. All social systems predicated on its continued existence among a distinguishable group or stratum must be destroyed.

While one must neither celebrate the "culture of poverty" nor plan or design "low cost" anything on the assumption of its continued presence, neither, however, should it be assumed that all modes of life among the poor and correlative to their poverty need be destroyed with its elimination. I believe some poor people live better lives than their more affluent brothers, but it is a celebration of man, not poverty, to acknowledge his genius at humane survival in the face of it.

Typically, occasions may vary along a number of dimensions, among them diffuseness, seriousness, regularity, hosted, etc. But there are more basic distinctions to be made among types of occasioning. One orientation is represented in the following autobiographical observation by René DuBose:

> Recently, during a discussion by a small group about creating parks in New York City, one of the representatives of the black community said, 'That's not what we want; what we want is a stage.' I didn't understand what he meant until the next day, when I realized that what he means by stage is an environment where he can act his own life, according to his own wishes. That obviously differs enormously from one person to the other, from black to white, and from man to woman. It immediately imposes the need for introducing a diversity of stages of environment in any community that is to be successful.
>
> As a young boy, I was raised in the industrial suburbs of Paris. The great difference between growing up there and growing up in New York City or any other large American city is that when I lived in that Paris suburb I could, within a few minutes, walk to ten, twenty, thirty, forty different environments, in which I could act out the different aspects of my life. There were public squares where everybody goes to gossip and engage in small, very human interchanges of life; then there were romantic spots along the river where maids and children and lovers could get together when the weather permitted. There were fashionable parks where people could go and play some other aspect of their life, and then there were those extraordinary parks near the university where people liked to engage in stimulating, challenging talk. In other words, there were a multiplicity of environments where one could act out the different aspects of one's potentiality. Each person could select his stage. That's what that fellow had in mind, I believe, when he said, 'What we need is a stage,'--a kind of environment suitable for the act that you want to make of your life.
>
> That certainly introduces immense complexity into planning a city, but I think we exaggerate those complexities. It looks difficult to create because it has been so foreign to Americans, but the plain fact is that's the way it is all over the rest of the world, so I don't see why it couldn't be done here. I want to emphasize that it's only through diversity of environment that true freedom can exist, and if there is no place where you can act your freedom, there is no freedom. (24)

This is an important statement in its delicate connection of such social-occasional activities as play, display, conversation and romance with concrete physical place and in DuBose's recognition that such a relationship is deeply associated with as elusive a thing as human freedom itself. His admonition to American city planners is equally important. But let's look more closely, albeit out of context, at what he has made of the black community representative's use of the dramaturgic analogy in calling for a "stage."

Dubose's image of an urban round of occasions and their locations is interesting in that the picture he paints is of a highly differentiated urban environment within which a varied set of social activities takes place, each corresponding to relatively fixed locales. No doubt, these river banks, parks and squares were not specifically designed and built to contain or conform to the subtly different social forms taking place in them. In all probability the activities became locale-fixed as an organic result of that great city's traditions. The image upon which DuBose is operating is based on his experiences within that tradition, and, unlike others who may more properly be called planners or designers, he has made a useful observation from his own life experiences generalizable to others with unlike experiences.

But I suspect--not having been there, I do not know--that the black man was likely to have had something different in mind in speaking of a stage. I do not intend to hinge this discussion on the likelihood that he did, but to point up with this example a different relationship between locale and social-occasion than is commonly imagined, when thought of at all: in contrast to the compelling image DuBose presents, a stage can also be seen as a single space or place in which a variety of actors can achieve certain freedoms by acting out many different aspects of their individual and collective lives.

Put more generally and technically, this discussion can be based in two related views of occasion-adequate spaces taken to be characteristic of the urban poor in general and, stylistically speaking, of the black urban poor in particular. In this case occasion-adequate space can be seen as 1) single spaces rendered adequate almost exclusively by the details of a social order regulating the character and emergence of occasions in those particular spaces over time. Such (interchangeable) spaces house now display, now play, now assignations, now casual conversation or group argument, etc., with all such changes in its use subject to a regulatory order which stresses, not the serial shift to occasion-specific spaces, but redefinition (re-designation, re-convening, re-provening) of that space for a new occasion through occasioning *acts*.

Correlatively, 2) *a single group can, through regulated occasioning acts, render various locales occasion-adequate for varied purposes*. Seen either way, occasion-adequate spaces are, in this conception, much more a sociological matter of mutuality in the comprehension of group-regulated occasioning acts in time than they are of social occasions being attached to fixed physical locations. In terms of the DuBose example, this puts the "stage" *and* the act in the social order of a people rather than in the socio-(particular) physical. Stage and act become portable in time in a single space and to interchangeable spaces in time.

Obviously there are class factors at play here. Among the urban poor this use of space is determined both by the paucity of space and the unpredictable temporal juxtaposition of work, play, "business," etc., occasions among those who must, for example, get their status or get a living by their wits. Where money is scarce, goods and transactions are often illegal. One must be able to move easily among business and other occasions. A common solution intermediate to the two being described here is that exemplified in "the oldest established permanent floating crap game in New York" (25).

But while class as reflected in available spatial resources is important, "controlling for it" (figuratively speaking of course), ethnic style still makes its imprint. Ethnic groups often make self-chiding jokes about their relationship with time, for example, a resource more generally available to the poorer of them. For many years black Americans would joke that a meeting was to be held at 8:00 P.M., "C.P. (Colored People's) Time." And some English Jews call the same tendency to be variably late "J.M.T." (Jewish Mean Time). I will want to take these stylistic differences more seriously and speak about C.P. space, although I will not call it that here.

Some Specimens from Community Studies

Systematic research on urban black communities has only recently become florid, but is firmly rooted nonetheless. In that research tradition the spatial and social-occasional activities of black people have often been very carefully described, of course, never by that name. The most famous of these studies is that of Drake and Cayton. Based on research conducted in the '30's and '40's, it is rife with descriptions of formal and informal gatherings and occasions surrounding and making up the daily life of the black communities of Chicago's Bronzeville (26). Even more impressive for its thoroughness is W.E.B. DuBois' study of *The Philadelphia Negro* published in 1899! His chapter, "The Environment of the Negro," contains a section on "Social Classes and Amusements" which compares favorably with most contemporary work in terms of alertness to what we here call social-occasional life (27). But for sheer alertness to what I have loosely called the "shell" of formed up social occasional life among the black urban poor, nothing compares with the recent rash of studies by white social scientists. These writers are often very acute at seeing and making problematic the outside features of black social-occasional life. Like all anthropologists, these observers often miss the meaning--the content in the form--a matter with which their contemporary black counterparts are almost exclusively concerned, but they seldom fail to describe the life they see in terms impossible or irrelevant for those in it to have done. As a consequence, I find these recent studies by "outsiders" very helpful in the thinking out of the present problem.

Consider Ulf Hannerz' description of black streetcorner life in Washington, D.C.:

> Many streetcorner men, . . . spend a great deal of their time in clusters with other men at street corners or on the front staircases of the rundown houses. . . . Many of the men join the gatherings only in their spare time before or after work. Others belong to the spurious leisure class of the unemployed and spend a great part of their days, and sometimes a part of their nights, in the gatherings. There are usually some men who form a core membership of such a clique, participating in its get-togethers one day after another. Other men take part more occasionally, and now and then somebody joins the circle only for a single encounter as he happens to be on the scene in the company of one of the more regular participants. Almost never is a woman present. Possibly she may sit in (without contributing more than sporadic comments) if she is married to the man at whose house the gathering takes place, but most women prefer not to. The gathering begins and ends elastically as the men drift in and out of it, coming from home or from work, going to see a woman, or to a pool hall, or to a bowling alley. Although all this is usually referred to as peer group life /by sociologists/, it is clearly more a question of *ad hoc* gatherings

> than of well-delineated groups.
>
> Certainly the gatherings are not all the same. There are times when the men at the corner stand around without talking much, just watching what goes on around them. Sometimes they may play cards or shoot crap, and hardly anything is said that does not have to do with the game. If somebody, player or spectator, tries to get a conversation started then, at least some players will brusquely ask him to shut up. At yet other times, conversations become contests . . . (28).

Hannerz acknowledges but dismisses a possible interpretation of these gatherings as pure sociability in Simmel's sense (29) and develops an alternate interpretation of them as masculine mythmaking sessions.

Issues of content aside, Hannerz has outlined in this example the major elements of the all-purpose single-space social occasional format described earlier in which the loose but frequent gatherings move, on signal, through a variety of occasions. In what Hannerz describes as a group form somewhat less distinct and more ad hoc than that ordinarily construed sociologically to be a peer group, there is certain to be some sort of interpersonal division of labor. But the general type of gathering described here suggests that acts of designation (card game women excluded), convenience(re-positioning) and provenience (shutting up irrelevant conversation) are handled by various persons by occasion. The contrast, physically and temporally, with "bridge at Martha's every Thursday at eight" is obvious.

An example of the second orientation to space and occasion is found in Suttles' excellent study The Social Order of the Slum. Among gatherings of slum youth he finds

> it is fairly obvious that the boys rely on something other than explicit rules to establish common procedures and goals. Typically, when some of the boys arrive at their hangout during the afternoon, there is no previous agreement about what they are going to do. Generally, the practice is simply to 'come on the scene' and ask 'what's happening?' From then on, joint activities emerge crescively as situations present themselves. Probably the most frequent activity is gossiping about people in the neighborhood. On a Friday (payday) some of the older boys may 'chip in' for some beer or wine. From time to time they may start 'rapping' or insulting one another. Sometimes they pitch pennies for an hour or two. During weekends there may be a local dance or social, and some of them may go there. Often someone in the older groups will own a car, and all the guys will 'pile in' and go for a ride around the neighborhood, yelling and waving to the girls and other boys they know. Occasionally, all those present will rise and go to the nearby beefstand, the Tastee Freeze, the Good Humor truck, or a hot dog stand. If there is a fight, a fire, or wreck, everybody--adults and adolescents--runs to see it. Sometimes there are games: 'babies,' 'ringoliva,' 'war,' and so on (30).

Most American males can recall such periods in their youth, but among middle class people it is precisely the opposite of this seeming insouciance which is defined as "maturity." Whether or not the poor or black people have a monopoly on this mode of social-occasional operation, it is a characteristic pattern during the "role moratorium" phase of, especially, adolescent male life. While the continuation of this "adolescent" social-occasional pattern into adulthood would appear to be common among the poor, such a pattern is thought to be posirively regressive by what might loosely be called middleclass Americans.

But such a pattern of occasioning can also be seen as an effective solution to the problem, at least, of crowding which usually attends conditions of urban poverty. Among other things, a major problem identified by Goffman is dispatched:

> Once a social situation is referred back to the social occasion that sets the tone for the gathering in it, we must admit the possibility that the same physical space may be caught within the domain of two different social occasions. The social situation then may be the scene of potential or actual conflict between the sets of regulations that ought to govern. (31)

The problem is managed in at least two ways, judging from our two examples: One is, in effect, a socialization to space use among the poor which puts the major responsibility for occasioning in persons rather than in locations. Secondly, spoken language becomes the effective device for occasioning acts. Occasion-adequate space is rendered so in conversation, and, while it is easy to be wrong, it is difficult to overinterpret the language used in such occasioning. Thus the concentration placed on it in the example from Suttles and throughout that work and Hannerz'.

But the existence of this primarily outdoor pattern has another basis and, as a location for social occasions, another interpretation. Suttles found in one of the Chicago districts he studied that eighty per cent of blocks had at least one social-occasional prop (my terms, not his) like an old sofa, auto seat, bench and even a television set on the sidewalk. Weather permitting, this device not only provided relief from the pressures inside the small dwellings, but provided some insulation of the, often problematic, personal life conducted inside from those in the neighborhood to whom they are particularly vulnerable due to the very active communication network operating in the community. But he also contends that

> the household planning and preparation for visits which are so prominent in more affluent neighborhoods is almost entirely lacking in the.... area. Telephone calls are seldom made before people 'drop in.' Advance invitations are even more uncommon and most prearranged domestic gatherings follow the annual cycle of customary holidays (Christmas, Thanksgiving, New Year's Eve, Lent) rather than individual convenience. Formal gatherings tend to be equally rare; cocktail parties, formal dinners, teas, and invitational parties are almost unheard of. Once started, then, domestic exchanges subject the residents either to unpredictable exposures or to additional confrontations from which they cannot easily retreat. Moreover, the gatherings within their households are not sufficiently guarded by the formalizations that keep a 'safe distance' between [those] present (32).

Save for the central culture's major markers, Christmas, etc., the round of occasions which make up the expected part of, say a designer's, occasional affairs (e.g., cocktail parties, formal dinners) are lacking among this group. Also missing, of course, are the occasioning acts which produce such gatherings, *viz*., invitations, announcements, formal telephone calls, etc.

This discussion from the literature is not intended as "proof" of the argument being presented here, but to point with illustrative empirical materials to what may be a compelling mode of occasioning to which more attention might be paid by planners and designers who ordinarily approach such situations with totally different life-conduct images. Let us look now at some type differences in occasions suggested by this contrast.

Occasions and Occasion Acts: A Typology of Gatherings in Urban Black Communities

It is appropriate now to propose a typology of occasions, occasioning acts and spaces which would appear distinctive to the community forms under discussion. Such a typology is necessarily relative and is not regarded as exclusive but *emphatic modes* characteristic of their occasioning activity. Two qualifications are in order: 1) Intertwined here are issues of indoor-outdoor and public-private spaces. The typology is, at this moment, general including not only houses, stoops and yards, but street corners, churches, pool halls, bowling alleys, liquor stores, barbershops, parks, etc.; 2) the proposed types derive from a survey of literature like those from which our specimens are drawn, from previous field investigation, and upon investigation currently underway. Further examples, elaboration, tests and application await the expansion of current work.

OCCASIONS: primary occasional distinction (pp. 6-12-6, 6-12-7) suggests two characteristic occasion forms: A. *Fixed Occasions*, fixed by acts of designation *not* by the physical structure of the occasion space or facilitating equipment. Such occasions are situation bound in time, tied to defined-in-time and named locales, but these latter are variable as are those persons convened in them; B. *Portable Occasions*, actively mobile and situation free, tied to a convened-in-time gathering the personnel of which is relatively fixed. More stable than, but dynamically equivalent to "bar hopping," with locales on route less limited, in terms of physical type and facilitating equipment.

OCCASIONING ACTS: Two broad types of acts which qualify those of designation, convenience and provenience. A. *Occasion Intensifying* acts tend to increase the variability of *focus* (33) in occasioned gatherings. For designation, for example, this involves re-instructing, re-including, etc. B. *Occasion Extensifying* acts tend to increase variability in *spacing, positioning*, etc. For designation, again, this involves re-naming, re-binding, etc. *The effect of both types of acts is to restructure the "shell" of the fixed or portable occasions*. C. *Occasion Maintaining* acts stabilize, for a time, the activities in fixed and portable occasions. The intersection of these occasion types and occasioning acts, along with examples of the specific types of occasions with which they are associated among urban black people are graphically represented in Table 1. Space limits prevent detailing of a variety of complementary occasions spaces such as those which are occasion intensive, occasion extensive, occasion specific, etc.

Conclusion

Outlined here is a framework for the analysis of social occasions with suggestions for application to a segment of the urban world. The scheme is introductory and tentative. Further detailed case studies will reveal the utility of such a taxonomic and dynamic analysis of social occasions for planning and design. They are proposed here on the assumption that information derived from systematic analyses are of more general use than *ad hoc* information. The point of the approach is not to find a

Table 1

		Occasion Type	
		Portable	Fixed
Occasioning Acts	Intensifying	"walking" (doing business)	"rapping" (partying
	Extensifying	"cruising" (on the move)	"styling" (on stage
	Maintaining	Establishing an occasion route or circuit	Establishing an occasion "set" or hangout

people's pattern for occasioning and fix them in it, but for programmers to discover and acknowledge occasioning styles in their analyses of design problems allowing both for the style and possible changes in it among users. Obviously the poor of all ethnicities would and do chose more recognizably middle class modes of occasioning as they are upwardly mobile.

But, in addition to learning about a people to "tailor" designs for their existence and change, we may in doing so discover new possibilities for society at large. With the high probability of both increased crowding and leisure in the future, we are very much in need of new images of possible modes of occupancy of private and public spaces and places. Among other things, the, at present, extremely tight connection between our occasional life and the physical locales and equipment in which they must take place is just another way in which contemporary life is alienated and segmented. An understanding of occasions may give us some good ideas about designing better for what is and provide a foil for imaging what might be.

Notes

1. Important examples are: Kenneth Clark, Dark Ghetto, New York: Harper and Row, 1965; Lee Rainwater, Behind Ghetto Walls, Aldine, 1970; Elliot Liebow's Tally's Corner, Little Brown, 1967; Gerald D. Suttles, The Social Order of the Slum, University of Chicago,1968; Ulf Hannerz, Soulside, Columbia Univ.Press, 1969; John Horton, "Time and Cool People," Trans-action, 4:5-12 (April, 1967); Thomas Kochman, "Rapping in the Black Ghetto,"Trans-action,6:4 (Feb.,1969); William McCord, John Howard, et al., Life Styles in the Black Ghetto, New York: W.W.Norton & Co., 1969. 2.Sir William Holford, "The Built Environment: Its Creation, Motivation and Control," in Environmental Psychology: Man and His Physical Setting, Harold M. Proshansky, et al.(eds.) N.Y.:Holt, Rinehart, and Winston, 1970. 3. Constance Perin, With Man in Mind, M.I.T. Press, 1970. 4. W.Joseph Black, "A Farsighted Study and some Blind Spots," Architectural Forum, Dec.1968, pp.44-49, cited in Perin, op.cit., pp.79-80. 5. For a very interesting exploration of this topic see Howard N. Boughey, Jr., Blueprints for Behavior: The Intentions of Architects to Influence Social Action Through Design, unpublished Ph.D. dissertation, Princeton Univ., 1968, Ann Arbor: Univ.Microfilms #69-2726, 1969. 6. Erving Goffman, Behavior in Public Places:Notes on the Social Organization of Gatherings, New York: The Free Press, 1966; Encounters, Indianapolis: Bobbs-Merrill, 1961. 7. William R. Ellis, Jr., Operation Bootstrap: A Case Study in Ideology and the Institutionalization of Protest, unpublished Ph.D. Dissertation, UCLA, 1969, Ann Arbor: Univ. Microfilms #69-16, 903. 8. See Perin, op.cit., p. 63. 9. Goffman, Behavior . . ., p.4. 10. Barker, Roger, Ecological Psychology, Stanford, Calif.: Stanford Univ. Press., 1968. 11. Ibid., p. 18. 12. Loc.cit. 13. Barker,ibid ., pp. 18-19. 14. Ibid., p. 16, beginning "It is not easy, at first, to leave the person out of observations of the environment of molar behavior . . ." 15. Ibid., p. 8. 16. Barker, loc.cit. 17. Op.cit., p.24. 18. Op.cit., p. 8. 19. Op.cit. 20. Howard Boughey, "Time, Space, Occasion: An Analytic Scheme for the Study of Timing and Spacing Acts," Unpublished paper presented at the Canadian Sociology and Anthropology Assn., St. John's, Newfoundland, 1971, p. 12. Professor Boughey is at the Univ. of British Columbia, Dept. of Sociology-Anthropology. 21. Ibid., pp. 14-27. 22. For his explanation of this archaistic usage see ibid., p. 14. 23. Ibid., pp. 14-34. 24. Unpublished papers, Interdisciplinary Symposium, Mental and Physical Well-Being in the City, Roslyn Lindheim (ed.), University of California, Berkeley, 1969, p. 16. 25. The phrase is Damon Runyon's. From the musical "Guys and Dolls." 26. St.Clair Drake and Horace R. Cayton, Black Metropolis, New York: Harper and Row, 1962, Vol. II., pp. 416-417. 27. New York: Shocken edition, 1967, pp. 309-321. 28. Op.cit., p. 105. 29. Loc. cit. 30. Op.cit., p. 183. 31. Op.cit., p. 20. 32. Op.cit., pp. 77-78. 33. Goffman, op.cit., p. 24.

7: POPULAR IMAGERY

ENVIRONMENTAL IMAGERY: AN OVERVIEW AND TENTATIVE ORDERING

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Like much other environmental research in progress today, the study of environmental imagery is a field which knows no disciplinary bounds (1). Such diverse areas as anthropology, environmental design and planning, geography, history, psychology, and the study of literature are all offering their helping hands of scholarship. With such a varied academic task force at work, any attempt to survey and organize environmental imagery studies will probably be incomplete. Still, an attempt is made here to define the study of environmental imagery and to provide some order to the scattered work focusing on the subject.

A Definition of Environmental Imagery

In explaining the content of environmental imagery study, the first term to consider is "image." Used by the layman, the word usually means "a reproduction or imitation of the form of a person or thing," or "a mental picture of something not actually present" (2). So one speaks of his image of the Statue of Liberty, his image of a cumulus cloud, or his image of the President of the United States.

In academic fields, the term often assumes new, more precise meanings. In psychology, for example, "image" can be defined as "the generic term for all conscious subjective presentations of a quasi-sensory but nonperceptual character" (3). More simply put, the word here refers to a revived sense experience occurring in the absence of sensory stimulation, for instance, the succession of dream-like, phantasmal visions that one may sometimes experience as he lies alone in bed at night. In another field, the study of literature, imagery is usually defined as "the sensory content of a literary work" (4). For instance, in William Wordsworth's familiar poem, "I Wandered Lonely as a Cloud," the "golden daffodils . . . fluttering and dancing in the breeze" are images, as are the breeze that tosses the flowers "in spritely dance" and the dancers to whom the daffodils are figuratively compared.

In comparison to these exact definitions from psychology and literature, the meaning of imagery used in this introduction is of a more general nature. Its essence is cogently expressed in Boulding's book, The Image: Knowledge in Life and Society (5). Boulding's thesis here is that humans do not apprehend reality directly, but instead receive selective messages from their environment, the character of these messages determined by the transmitting mechanism and the individual's receiving mechanism. There are, then, no such things as "facts" in one's head, but only messages filtered through a changeable value system which is molded by such various sources as culture, social reference groups, and individual idiosyncracies(6). The resultant is the individual's image, or rather, a complex of images which includes the individual's mental impressions of his job, his employer, of his path to work, of his city, of the United States, of communism, of aborigines, of the universe, and so on without end. His image of each of these elements includes not only a visual picture--providing of course, the element is visually imageable--but also the values, symbols, evaluations, and other meanings he places on the element(7). For example, the inputs of a highschool education, the mass media, word of mouth, and other information sources may have generated in many Americans' minds an image--perhaps in this case a stereotype--of the Soviet Union as a vast, cold, and windswept plain which is inhabited by a morose but volatile, underpaid people who are autoless and dwell in poorly constructed, poorly equipped apartments of miniscule dimensions.

Each individual's collection of images is unique. As Kluckholn and Mowrer explain, "the fact that no two human beings can occupy the same point at the same time and that the world is never precisely the same on successive occasions means the physical world is idiosyncratic for each individual" (8). Still--though each individual's world view may be firsthand--there must be substantial agreement in images for members of the same group. After all, in order for members of the same political party to operate smoothly, they must each have a similar conception of goals, priorities, ideals, loyalties, and other needs. Boulding terms this shared world view a "public image" and writes that "this image is the basic bond of any society, culture, sub-culture, or organization" because it includes all the essential elements that are shared by the individuals participating in the group(9).

Each individual, then, holds a great collection of images in his head, a collection compounded of personal experience, learning, imagination, and memory (10); many of these images are shared in common by members of the same group. This introduction focuses on but a small portion of this great collection--images of the environment. Broadly defined, "environment" refers to "any condition or influence outside the organism, group, system, or whatever entity is being studied" (11). The concern here is with those elements of the environment--either natural or man-constructed--which the individual can identify and comprehend; from trees and buildings; to complete cities or particular regions, such as nations, megalopolis, or the South; to more generalized environments such as wilderness or suburbia. Craik suggests that environmental elements vary along at least two important dimensions: scale, and degree of human influence (12). Thus, a tree would be small scale and natural; a fountain, small scale and man-influenced; Niagara Falls, large scale and natural; the city of Chicago, large scale and man-influenced. Though these two dimensions are quite useful in classifying environmental elements, a third dimension--degree of environmental specificity--is more useful in environmental imagery studies. This dimension's polarities are specific environments, such as a particular city, landscape, building, or specific region, as opposed to generalized, often abstracted, environments such as the frontier, the countryside, the idealized neighborhood, or cities in general.

In analyzing images of various environments, whether specific or generalized, one will usually be interested in a specific group's public image of a particular environment. For instance, in what ways do various ethnic groups in a city cognize specific spaces, areas, and streets of a city (13)? How did the Eastern educated elite's dominant image of the western interior of the United States differ from that of potential settlers to the area (14)? How have American intellectuals felt about cities and the process of urbanization in the United States over history (15)? Closely related here are studies of individual and group images of environmental processes. How, for instance, do residents of potentially threatened areas perceive extreme environmental conditions such as storms, floods, drought, or snow (16)? What are the attitudes of various culture groups toward nature (17)? How did Europeans at the time of the Chrusades conceptualize environmental phenomena, such as the origins of mountains and rivers, or the workings of tides or weather (18)? Such diverse questions as these provide exciting avenues of inquiry for environmenta imagery studies.

An Overview of Extant Work in Environmental Imagery

Lynch has suggested that to be workable any environmental image should include three dimensions: first, identity, i.e., the environmental element must be recognizable from other elements of the environment; second, structure, i.e., the environmental element must relate spatially to the observer and to other elements of the environment; and third, meaning to the observer, "whether pracitical or emotional"(19). Relating these three dimensions to specific environments, generalized environments, and environmental processes, one might tentatively break extant environmental imagery studies into five types (20):

1. Studies of the identity and structure of specific environments.
2. Studies of the identity and structure of generalized environments.
3. Studies of the meaning of specific environments.
4. Studies of the meaning of generalized environments.
5. Studies of the meaning of environmental processes.

Studies of the Identity and Structure of Specific Environments

The first group of studies has largely focused on the urban environment. The most familiar work, of course, is Lynch's Image of the City, which has stimulated much subsequent study (21). The concern here is usually with the visual quality of a particular city, or, to use Lynch's terms, the "legibility" or "imageability" of the cityscape, the smoothness with which the city's physical parts can be organized into a structured whole in the minds of its residents(22). In his study, Lynch constructed composite maps of residents' "collective images" of three cities--Boston, Jersey City, and Los Angeles, collecting data by interviews, mapping procedures, and conductive walks. He discovered that in terms of identity and structure, city images are composed of five types of environmental elements: paths, nodes, edges, districts, and landmarks. Paths, for example, are the "channels along which the observer customarily, occasionally, or potentially moves" (23). Although there is much in Lynch's work that can be criticized (24), his techniques have been used in such various places as several Dutch cities, Tripoli in Lebanon, and Ciudad Guayana in Venezuela, with findings that suggest definite value in his approach (25). In regard to studies dealing with specific environments other than cities, it appears that little work has been done in analyzing identity and structure. At least one exception, however, is a study done by Stea, which focuses on individual and group perceptions of geographic distances and areas (26).

Studies of the Identity and Structure of Generalized Environments

Though work analyzing the identity and structure of generalized environments is presently meager, study here focuses on the spatial components of individual and group images of the ideal living environment, the ideal city, or the ideal neighborhood. Michaelson, for example, asked a sample of Italian-Americans and Irish-Americans in Boston to sketch a map of their ideal environment, first drawing house, then lot, neighborhood, and the entire city, labelling land uses and distances (27). The greatest part of his sample (thirty percent) preferred a purely residential environment, consisting of well-separated, single-family houses with a large nearby shopping center. Another group (thirteen percent) visualized single-family houses with such facilities as a grocery store, drugstore, church, and post office located in the neighborhood.

Work of this sort may also focus on images of generalized extant environments. In this regard, Cox has attempted to determine how individuals arrange city space in regard to patterns of population density, social class, land values, crime rate, and racial distribution (28). Using a group of students for his sample, Cox finds their image of the spatial layout of the city to be dominated by a concentric-ring pattern. The core in this pattern is visualized as a densely inhabited, lower class, black area of low land values and a high crime rate; around the core is a less-dense, white middle class ring of high land values and low crime rates.

Studies of the Meaning of Specific Environments

As in the first two groups of study, much of the work looking at the meaning a specific environment has for an individual or group has focused on cities. Strauss, for instance, writes of analyzing "the identifying characterization of any particular city, and the symbolic implication of that characterization for the quality of life it represents" (29) in his thorough book, Images of the American City. He points out that urbanites have at their disposal a great number of methods for reducing and simplifying the complexity of their urban environment and endowing it with meaning. Often, for example, a particular city is identified in terms of one symbol--the Golden Gate representing San Francisco, the French Quarter identifying New Orleans, the Manhattan skyline typifying New York. Such succinct symbols make "it possible to encompass the city's wide expanse" (30). At other times analogies and metaphors--either implicit or explicit--may be used to simplify the city's entanglement. Thus, a city may become "a factory, a madhouse, a frontier, or a woman"(31). Personification and the massing of adjectives that relate to the city are other techniques Strauss mentions that reduce the intricacies of the urban environment. In regard to the latter method, for instance, one visitor to Chicago penned in hyperbola:

> Call Chicago mighty, monstrous, multifarious, vital, lusty, stupendous, indomitable, intense, unnatural, aspiring, puissant, preposterous, transcendent--call it what you like--throw the dictionary at it! (32)

Besides analyzing methods of symbolizing specific environments, studies of meaning attempt to synthesize the various meanings of a specific environment to create a composite image of that environment. Firey, for instance, has looked at the meaning that the Boston Common has for the people of the city and concludes that the Common has become "a 'sacred' object, articulating and symbolizing genuine historical sentiments of a certain portion of the community. Like all such objects its sacredness derives, not from any intrinsic spatial attributes, but rather from its representation in peoples' minds as a symbol for collective sentiments" (33). Likewise, Strauss attempts to organize the many meanings linked with the city of Chicago. In summarizing the city's stockpile of imagery, he points out that "Chicago is represented as a great midwestern industrial and commercial city . . . a cosmopolitan city, a world city, great in size and aspiration, in attainment and fame" (34). Further, he writes:

> It is unquestionably a town marked by a certain amount of violence, vice, graft, and those other unpleasant accompanyments of big city life. But it is also, by popular representation, a midwestern city which embodies something peculiar to the region that is not possessed by cities located elsewhere in the nation (35).

In regard to work focusing on the meanings of specific environments other than cities, Elson looks at the content of American schoolbooks of the nineteenth century and includes discussion of the images of nation and nationality that these books project (36). Italy, for instance, is usually described as the residence of the Pope, the place American artists went for training, and, especially at the end of the century, the home of many future immigrants to the United States. The country is further portrayed as a land that was once great but now has retrogressed: "the Italians are depicted throughout as an artistic but degenerate nation. Italy, like Greece, is regarded as the home of the arts. But in all the books there is more stress on their decline than on their pre-eminence . . . ." (37).

In another study concerned with the meaning of a specific environment, Bowden reconstructs the various images of the Western interior held by the American public between 1825 and 1870 by analyzing in detail, textbooks, newspapers, letters, diaries, travellers' accounts, and surveyors' notes of the period (38). He concludes that the educated elite of the Eastern United States conceptualized the interior as a desert over the period, whereas the potential immigrant to the West who lived on the frontier east of the Missouri cognized the area as what it more accurately was: a place of cultivable prairies. Other work focusing on meaning looks at such specific but varied environments as a shopping center in Bristol, England (39), the Great Plains (40), and the British and North American landscapes(41).

Studies of the Meaning of Generalized Environments

Studies of this sort--of which the three papers for this session are examples-- deal with the meaning of generalized environments. Again, much of the work in this area has focused on the urban environment--the attitudes, feelings, and impressions that individuals and groups have had or have of city life in general. A useful illustration is the Whites' *The Intellectual Versus the City*, which analyzes the perspectives of American intellectuals toward cities from the middle eighteenth century to the recent past and concludes that the dominant views were antagonistic (42). In capsulizing this anti-urban image, the Whites contend that American intellectuals have thought of the city as "too big, too noisy, too dusky, too dirty, too smelly, too commercial, . . . too fast, too artificial, destructive of conversation, . . . too lacking in manners, too mechanical, destructive of family, tribal and patriotic feeling"--in short, a negative environment for a host of divergent reasons (43). For all its complexity, however, the Whites conclude that the anti-urban image can be divided into two contrasting historical stages loosely separated by the Civil War: "one in which romanticism was employed in attacking the city for being overcivilized; and another stage in which the city was accused of being undercivilized by anti- or at least non-romantics"(44).

Other researchers analyzing the city image in America have challenged the Whites' negative portrayal and demonstrated the existence of pro-urban views (45). Freidel, for instance, points out the positive image of the city portrayed by the civic booster tradition in the United States. He mentions one such booster of Baltimore who described cities as the home of the merchant, the patriot, and the great scholar and artist, and then concluded: "free cities, considered in this light, are the repositories, preservatives, and nursuries of commerce, liberty, and knowledge" (46).

Besides the many studies of studies focusing on the meaning of the American city, analyses of other diverse, generalized environments are represented in the imagery literature. Suburbia (47), the wilderness (48), the frontier (49), ruralism (50)--images of all these environments have been researched to varying degrees. Nash, for instance, looks at the changing conceptions of wilderness in the United States and concludes that "for most of their history, Americans regarded wilderness as a moral and physical wasteland fit only for conquest and fructification in the name of progress, civilization, and Christianity" (51). Only slowly has the notion of wilderness preservation and appreciation developed in the mind of the American public.

Studies of the Meanings of Environmental Processes

The last group of imagery studies focus on the meanings of environmental processes and has considered such topics as perceptions of environmental hazards and conceptions of hydrologic, climatic, and geologic events. In a study of Midwestern farmers whose land suffers from low moisture levels, Saarinen is in part interested in the farmers' comprehension of of the threat of drought(52). Using a questionnaire and a thematic potential analysis (a series of picture-cards for each of which the respondent tells a story) to elicit responses, Saarinen concludes that the farmers' perceptions of drought appear to vary and depend on the degree of aridity of the land they occupy.

Similarly, Wright is partially concerned with the meanings of environmental processes familiar to Western Europeans at the height of the Middle Ages in his *Geographical Knowledge at the Time of the Crusades* (53). Winds, rains, and storms, for instance, were thought by the unlearned to be manifestations of magical powers or evil spirits. Contemporary scholars sometimes held more logical, but often no more accurate, explanations. For instance, William of Conches, one of the better students of natural sciences at the time, believed that winds were in part the result of the destruction and flattening out of clouds (54). Wright also discusses the conceptions at the time of other environmental phenomena such as tides, geysers, volcanoes, glaciers, and climates. Other work interpreting various individual and group images of environmental processes, including attitudes toward nature, is that of Glacken and Tuan (55).

Conclusion

This introduction has suggested that work in environmental imagery can be categorized into five types: studies of (1) the identity and structure of specific environments, (2) the identity and structure of generalized environments, (3) the meaning of specific environments, (4) the meaning of generalized environments, and (5) the meaning of environmental processes. Much of the imagery work mentioned here, of course, can not be neatly accommodated in one category, but instead overlaps into two or more types. Strauss's work on urban imagery, for example, is concerned with the meaning of not only specific cities, but also cities in general. Since Strauss's purpose is to clarify the complexity of Americans' ambivalent attitudes toward their cities, such overlap is both necessary and natural. Similarly, in his Geographical Lore at the Time of the Crusades, Wright discusses contemporaneous perceptions of geographic regions and images of the cosmos, in addition to describing the meanings of environmental processes for people of the time. Again, such discussion is in accord with Wright's goal of depicting the sum geographical knowledge held by Europeans at the time of the Middle Ages. In short, the purpose of the study--be it an analysis of Americans' feelings for their cities, a description of medieval Europeans' notions of environmental phenomena, or whatever--determines the particular category (or categories) of environmental imagery study in which the researcher will be working. The function of the five-fold typology marked out above, then, is not to dictate the limits of a particular environmental imagery study--only the researcher's subject and goals can determine such parameters. Instead, this categorization system serves as a tentative classification of the great variety of studies in environmental imagery. Hopefully, it provides a logical ordering of these diverse studies and suggests to at least a few researchers the great scope of the field and their place in it.

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The other papers of this session focus on environmental imagery derived from popular sources (e.g., popular literature, art, and the mass media). In relation to the tentative ordering above, each of these studies relate most closely to work focusing on the meaning of a generalized environment: Handlin examines the evolving image of the single-family detached house in America; Gleason suggests three imaginative modes that have shaped most writers' images of the American city; Donaldson looks at the image of suburbia projected by recent articles appearing in mass circulation magazines.

Notes

1. The word "field" is to be taken rather loosely here, since environmental imagery study implies different things to different disciplines. In the social sciences, the "field" of environmental imagery is probably better identified as a sub-study of environmental cognition or environmental perception. If considered as such a subfield, imagery study might alternately be spoken of as research in spatial cognition; work in environmental attitudes, dispositions, or preferences; or study in geosophy (for a description of spatial cognition, see Hart, R.A., and Moore, G.T., "The Development of Spatial Cognition," in Cognitive Mapping: Images of Spatial Environments, Downs, R., and Stea, D. [eds.], Chicago: Aldine-Atherton, in press. Craik places much of the imagery work to be mentioned here under the research category of "attitudinal responses;" see Craik, K., "Environmental Psychology, in New Directions in Psychology 4, Newcomb, T., [ed.], New York: Holt, Rinehart, and Winston, 1970, pp. 1-121, esp. pp. 76-77. For a definition of "geosophy," see Wright, J.K., "Terrae Incognitae: the Place of Imagination in Geography," Annals of the Association of American Geographers, 37 [1947], 1-15; reprinted in idem, Human Nature in Geography, Cambridge: Harvard University Press, 1966).

Studies need not necessarily use the term "image" to qualify as analyses of environmental imagery. For example, none of the three following papers use the term as a focus, yet they can all be considered as examples of environmental imagery study. Likewise, much of the literature referred to later will not explicitly use the term, yet the concept of image as defined in this introduction is implicitly implied in these studies.

2. Webster's Seventh New Collegiate Dictionary, Springfield, Mass.: G.&C. Merriam Co., 1963, p. 415.

3. Holt, R. R., "Imagery: the Return of the Ostracized," *American Psychologist*, 19(1964), 254-464, on 255.

4. Barnet, S., et. al., *A Dictionary of Literary Terms*, Boston: Little Brown and Co., 1960, p. 49.

5. Boulding, K., *The Image: Knowledge in Life and Society*, Ann Arbor: University of Michigan Press, 1956.

6. *Ibid.*, p. 14.

7. Images of more abstract elements, such as socialism or a political group, can not usually be cognized pictorially; usually the element is kept alive mentally through symbolic association. For example, Boulding suggests that some individuals symbolize the Democratic Party as a donkey, "active, agile, clever, a little unsure of himself, a bit of an upstart, quick, sensitive, a little vulgar, and cheerfully absurd"(Boulding, p. 110).

8. Kluckholn, C., and Mower, O.H.,"'Culture and Personality': a Conceptual Scheme," *American Anthropologist*, 46(1944), 1-29 on 13; originally quoted in Lowenthal, 251(see note 10).

9. Boulding, p. 64.

10. See Lowenthal, D., "Geography, Experience, and Imagination: Towards a Geographical Epistomology," *Annals of the Association of the American Geographers*, 51(1961), 241-260, on 260.

11. Craik, "Environmental Psychology," p. 65 (see note 1).

12. *Ibid.*, pp. 65-66.

13. e.g., Strauss, A., *Images of the American City*, New York: The Free Press of Glencoe, 1961, chap. 4.

14. Bowden, M., "The Great American Desert and the American Frontier, 1800-1882: Popular Images of the Plains," in *Anonymous Americans* Hareven, T.K.(ed.), Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971, pp. 48-79.

15. e.g., White, M. and White, L., *The Intellectual Versus the City*, Cambridge: Harvard University Press, 1962.

16. e.g., Kates, R.W., *Hazard and Choice Perception in Flood Plain Management*, Chicago: University of Chicago, Dept. of Geography, Research Paper No. 78, 1962.

17. e.g., Tuan,Y., "Attitudes toward Environment: Themes and Approaches," in *Environmental Perception and Behavior*, Chicago: University of Chicago, Department of Geography, Research Paper No. 109, 1967, pp. 4-17.

18. Wright, J.K., *Geographical Lore at the Time of the Crusades*, New York: American Geographical Society, 1925.

19. Lynch, K. *The Image of the City*, Cambridge: The M.I.T. Press, 1960, p. 8.

20. It should be emphasized here that this classification of environmental imagery studies is only tentative. Many other typologies would probably function as well or better. For instance, categories based on environmental scale, degree of human influence, or psychological process(perceptive-cognitive-affective modalities) might be useful.

21. e.g., Appleyard, D., "Styles and Methods of Structuring a City," *Environment and Behavior*, 2(1970), 100-117; de Jonge, D., "Images of Urban Areas," *Journal of the American Institute of Planners*, 28 (1962), 266-276; Gulick, J., "Images of an Arab City," *Journal of the American Institute of Planners*, 29 (1963), 179-97.

22. Lych, p. 9.

23. *Ibid.*, p. 47.

24. e.g., Wood, D., *Fleeting Glimpses: Adolescent and Other Images of the Entity Called San Cristobal Las Cassas, Chiapas, Mexico*, unpublished MA thesis, Clark University, Worcester, Mass., 1971.

25. See respectively, de Jonge, Gulick, and Appleyard (note 21).

26. Stea, D., "The Measurement of Mental Maps: An Experimental Model for Studying Conceptual Spaces," in *Behavioral Problems in Geography: A Symposium, Studies in Geography, #17*, Northwestern University, 1969.

27. Michaelson, W., "An Empirical Analysis of Urban Environmental Preferences," *Journal of the American Institute of Planners*, 32 (1966), 355-360.

28. Cox, K., "Spatial Schemata: A Conceptualization and Application to Intra-urban Space," unpublished paper presented at the Association of American Geographers' conference, April, 1971.

29. Strauss, p. 5 (see note 13).

30. *Ibid.*, p. 11.

31. *Ibid.*, p. 14.

32. Ibid., p. 13.

33. Firey, W., "Sentiment and Symbolism as Ecological Variables," in Studies in Human Ecology, Theodorson, G.A. (ed.), Evanston, Illinois: Row, 1961, pp. 253-262.

34. Strauss, p. 33.

35. Ibid., p. 33.

36. Elson, R.M., Guardians of Tradition, Lincoln, Nebraska: University of Nebraska Press, 1964.

37. Ibid., p. 147.

38. Bowden, see note 14.

39. Downs, R.M., "The Cognitive Structure of a Shopping Center," Envrionment and Behavior, 2 (June, 1970), 13-39.

40. e.g., Lewis, G.M., "Changing Emphases on the Description of Natural Environment of the American Great Plains Area," Transactions of the Institute of British Geographers, 30 (1962), 75-90.

41. In regard to the British landscape, see Lowenthal, D., and Prince, H.C., "The English Landscape," Geographical Review, 54 (1964), 309-346; also, idem., "English Landscape Tastes," Geographical Review, 55 (1965), 186-222. For the North American landscape, see Lowenthal, D., "The American Scene," Geographical Review, 58 (1968), 61-88, and reprinted in Environmental Psychology, Proshansky, H.M., Ittelson, W.H., and Rivlin, L. (eds.), New York: Holt, Rinehart, and Winston, 1970.

42. White, M., and White, L., see note 15.

43. Ibid., p. 222.

44. Ibid., p. 228.

45. e.g., Callow, A.B., "The City in the American Mind," American Urban History, Callow, A.B.(ed.), New York: Oxford University Press, 1969, pp. 349-352; Glaab, C.N., and Brown, A.T., A History of Urban America, New York: Macmillan, 1967; Freidel, F., "Boosters, Intellectuals, and the American City," in The Historian and the City, Handlin, O., and Burchard, J.(eds.), Cambridge: The M.I.T. Press, and Harvard University Press, 1963, pp. 115-120.

46. See Freidel, p. 116, note 45.

47. e.g., Donaldson, S., The Suburban Myth, New York: Columbia University Press, 1969.

48. e.g., Nash, R., The Wilderness and the American Mind, New Haven: Yale University Press, 1967; Carroll, P.N., Puritanism and the Wilderness, New York: Columbia University Press, 1969.

49. e.g., Smith, H.N., Virgin Land: The American West as Symbol and Myth, New York: Vintage, 1957.

50. Marx, L., The Machine in the Garden: Technology and the Pastoral Ideal in America, New York: Oxford University Press, 1964; Weimer, D.R. (ed.), City and Country in America, New York: Appleton-Century-Crofts, 1962.

51. Nash, p. vii, see note 48.

52. Saarinen, T.F., Perceptions of the Drought Hazard on the Great Plains, Chicago: University of Chicago, Department of Geography, Research Paper No. 106, 1966.

53. Wright, see note 18.

54. Ibid., p. 172.

55. Glacken, C.J., Traces on the Rhodian Shore: Nature and Culture in Western Thought From Ancient Times to the End of the Eighteenth Century, Berkeley: University of California Press, 1967; Tuan, see note 17.

THE DETACHED HOUSE IN THE AGE OF THE OBJECT AND BEYOND

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For the past few years housing has been proclaimed the building type of the 1970's. It is not hard to figure that the same children that caused the crisis in school building in the 1950's and the boom in university construction in the 1960's will make demands of similar magnitude for new housing as they reach maturity and start to have families. Projected numbers vary, but ever since the Report of the President's Committe on Urban Housing of 1968 and the subsequent Housing and Urban Development Act everyone connected with building has come to accept that there will be a previously unequalled amount of housing built in the 1970's. (1)

This prospect affords the opportunity to take a fresh look at what is meant by "housing." Past government housing programs have always been in part concerned with setting new definitions of an adequate house. But recently this has hardly been emphasized, at least in official circles. Systems of construction, management, and financing have received more attention, and, where design is concerned, the scale of a large development or even a new community is most often mentioned.

As necessary as this broad focus may be, it leaves open the possibility that on a more specific level the housing built in the near future will either be out of step with some new social requirements or at least may not seize upon an opportunity for creative innovation. Besides, these two scales of consideration are not disconnected. In the last century the quest by individuals for certain particular housing conditions was undertaken along similar lines by a multitude of people and therefore became a dominant factor in the creation of a kind of general urban form. This interplay of different levels of environmental concern is likely to continue in the future.

By concentrating on the development of the single family detached house as the ideal setting of American domestic life, this paper will not only define the critical qualities of these housing conditions but will also discuss how they came to be so widely accepted as desirable. It will also suggest that as we enter the twenty-first century we may still be guided by ideas of housing that had their origin in the late eighteenth or early nineteenth century. The implication, which will be brought out in the end of this essay, is that no matter how powerful this ideal may still be in our imaginations, its original context may have changed and therefore it may be a hindrance in creating a viable social organization through the environment in the future.

A major change occurred in American housing at the beginning of the nineteenth century. It was part of a larger social transformation that is still having profound repercussions.(2) This was not a sudden break with the past, and, consequently, caused little direct comment at the time, but one contemporary, Horace Bushnell, seems to have fully understood the implications of what was happening, especially with regard to everyday living environments. Bushnell was an influential minister, living in Hartford, Connecticut, but with a national audience through his published sermons. In a speech entitled "The Age of Homespun," made on the occasion of the centennial celebration of the County of Litchfield, Connecticut, he summarized the significance of the changes in the previous hundred years. (3)

Bushnell focussed on what went on in American homes. He called the momentous changes a "transition from mother and daughter power to water and steam power." In short, what previously had been called "domestic manufacture" was neither "domestic as being made in the house, nor manu-facture, as being made by the hands." (4) The change from homespun clothes to factory-made clothes seemed to typefy this transition. In the century that Bushnell was reviewing, an entire sector of activities that used to happen in the home, whether in the country or in a city, disappeared. The house became less self-sufficient as more things could be bought pre-made or pre-prepared. Activity in specialized places of work, offices or factories, superseded what previously took place within the house or in an extra room or wing, and even what are now called services were brought to the house from remote sources. So not only were the activities of the home affected, but the links between individual or family and the society at large were reshaped and extended.

Bushnell was not sentimental about the period gone by. Life in the Age of Homespun had been difficult. Resources were meager, the working day long, and most homes lacked basic comforts. Yet these conditions had what he called an "old simplicity," a discipline which he thought needed an equivalent in the new period. The entire gamut of reform movements in the first part of the nineteenth century can be seen in part as an attempt to determine what this equivalent was and then how it could be propagated. Bushnell was especially interested in the upbringing of children; he advocated a kind of nurture. Parents determined the fate of children through their behavior, their attitudes and their surroundings. "The spirit of the house is breathed into his nature day by day. The child breathes the atmosphere of the house....He sees the world through his parents' eyes. Their objects are his." (5) As a minister Bushnell thought that religious behavior was the best approach to the creation of this kind of environment, so when he spoke about 'atmosphere,' he referred to it in a general way.

Faced, however, with the responsibility of creating a context for a new kind of family life--one that was different than that which existed in the Age of Homespun, but which hopefully would engender the qualities of the "old simplicity"-- at this time doctors, architects, and other concerned citizens were making a more careful evaluation of the effects of "breathing," "atmosphere," and "objects." If this interest did not come directly from Bushnell's words, then it was derived from the general framework of ideas which his writings encompassed and which, because they were shared by so many contemporaries, allowed others to respond sympathetically to him. The result of the realization that environments had an active effect on behavior was the beginning of a scientific or, at least, analytical approach to the nature and organization of building and spaces at the scale of housing.

A picture from a report made by a group of doctors on living conditions in New York City illustrates the novelty of this approach and gives a glimpse of its consequences. (6) The crudeness of the drawing belies its significance. It shows a man in relationship to rooms of different volumes. A space in this case is being measured not in terms of the proportions of the body or an aesthetic principle, but instead by a human, functional requirement--how much air is necessary for breathing over a given span of time. This is one of the first indications of an attempt to analyze how people lived in spaces and as such marks a new departure in thinking about architecture.

The analysis of environment that started in the early nineteenth century was not limited to understanding the nature of particular biological processes in spaces. Although motivated primarily by a strong interest in public health, this was part of a more general attempt to understand how human activities were deployed in spaces. In order to know how buildings were used, it was necessary to make some assessment of what activities were to take place within, what space-occupying objects and furnishings were needed, and what environmental conditions were best for each activity. In other words, "house planning" as a phrase was first used in this period. Plans from books that dealt with how to care for the home are particularly instructive. (7) They are the first examples of drawings in which furniture is shown in plan as part of the architecture, because architecture is seen as more than a sequence of spaces shaped or enclosed by walls. By the mid-nineteenth century, houses had become containers of activities in a properly controlled environment with the right furnishings and objects.

The goal of this analytical view of the home was to create an organized environment that would be conducive both to physical health and the spiritual well-being of the family. The emphasis was on definition and differentiation. Spaces were shaped to accommodate specific activities according to their nature. Certain functions would only take place in spaces designated and equipped for them. As a result, the house became the scene of a family ritual; activities by individuals or by the family together were deployed from space to space as the day--or to a lesser extent the week or season--progressed.

Spaces within a house came to be defined by activities--living room, dining room, bedroom, kitchen, etc. But even within a space the area was further broken down. The awareness of how a person's health depended on the condition of his environment elicitied a sense of appropriateness about the storage and placement of objects, especially food and clothing. Elaborate systems of closets, cupboards and other partitions or subdivided spaces were characteristic of this new house. Much has been written about the invention in this period of the balloon frame as a rapid system of construction.(8) But it also had a purpose as a means that allowed this highly particular space to be partitioned. Its development paralleled the availability of ready-to-install cupboards, drawers, and shelving. "Everything in its place and a place for everything" was an apt contemporary phrase that described this sense of appropriateness.

This activity-specific space system was reenforced and even fixed by the furnishings and finishes, the system of objects, which served as a functional and symbolic statement of the nature of paticular areas. Not only did such items by their presence establish the identity of a room, but through their design they revealed that there was a sense of permanency to this identity. In addition, depending on the materials, cost, or other measure of value, the furniture and finishes indicated the significance for the life of the family of the activities associated with an area.

If this characterization of the home seems familiar today, it is only because this concept of living has been so widely accepted and it emphasizes the significance of the separation from the Age of Homespun. For most people the idea that activities like eating or sleeping could be manipulated for greater comfort and health by adjusting the environments in which they occurred was completely new. The array of objects we take for granted as necessities (chairs, tables, dishes, knives, forks, clothes for different seasons, etc.) was extremely limited. One byproduct of industrialization was that it made available on a wide scale things which previously either had been considered cherished possessions or were only available to the wealthy. It is now hard to realize the function and importance of a diagram of how to set a table. (9) At the time, however, the utensils and the sense of order it reveals were both unfamiliar to most people. Sometimes the directions for living in and running a household of objects and manners seem to have an air of pretentious gentility, but they used to serve the legitimate purpose of guiding people in making the bewildering and painful adjustment from a traditional to a modern society. (10)

Few architects doubted that the best placefor this kind of life was a detached house. This was an accepted assumption, but it is hard to pinpoint its exact origins. Physical separation was favored from the point of view of public health by the doctors who wrote about the living conditions in New York. They found that diseases tended to spread in contiguous buildings. Often a large portion of the people in one block would be affected by a certain disease, but few were similarly afflicted in the next. This was particularly so when they shared facilities, especially privies. So the doctors recommended a situation in which contiguity did not exist. In cities this was impractical, but in crowded circumstances the emphasis was to cut down shared living spaces and to create the maximum conditions of family privacy. (11)

The growing information about the circumstances of public health, the wide availability of wood which, as a combustible material, was not good for contiguous buildings, the existence of cheap and lightly taxed land, and the ease of buying or selling a discrete piece of property all helped the single family detached house to emerge as an ideal building type. But these factors do not fully explain why, for instance, a row house type, similar to what developed in England, did not catch on in America. Ultimately, the single family detached house became popular because it was espoused as the ideal seat of domestic life by several vociferous and influential advocates who concentrated more on depicting the virtues of living in such a situation than on making a rational analysis of overall housing needs.

The architect, Andrew Jackson Downing, became the chief proponent of the house in a country setting. His many books and articles on architecture, landscape architecture, and horticulture emphasized the importance of the deliberate design of all elements of the environment as necessary backdrops for, or even participants in, the life of manners and etiquette that he presupposed would exist in these places. This writing went through many editions, but almost more important than Downing's works was the example of the man himself. Because of his supposed unflagging dedication to art in the guise of architecture and landscaping, he was continually acclaimed by contemporaries as one of the few purely motivated and disinterested Americans of the time. Downing's example was particularly outstanding since everyone else seemed to succumb to money and fashion. The tragedy of his early death in 1852 in a steamboat accident on the Hudson even enhanced his reputation and furthered the sense of correctness about the causes with which he became associated. "In the manner of Downing" became a household phrase, a description not just of a universally approved kind of house or landscape, but of an entire way of life. (12)

This type of domestic conduct and its appropriate house form received publicity from others who were not architects. Over the span of several years Nathaniel Parker Willis, the editor of the Home Journal, lived in a house called Idlewild, designed by Downing's partner. He published weekly accounts of household events there, so subscribers continually read about the joys of living with one's family in the country. Downing often started an article or book by stating that the self-sufficient farm was the truly American way of life. As a Whig, he did not mention Jefferson, but hearkening back to the Jeffersonian ideal was an effective rhetorical device. Downing and Willis, however, were not as conservative as, for instance, Cobbet was in England. They saw a new possibility. As Willis put it: "Business in the city, living in the country." (13) New railroad lines made this bi-location possible and, because of the impulse to have this kind of domestic life, the rapid suberbanization of

American cities started after the Civil War.(14)

The element of nostalgia for farm life that Downing expressed was also a powerful factor in establishing the context of the detached house, The impulse was well summarized in Whittier's popular poem Snowbound. In these verses he praised the self-contained life in a farm house which had been temporarily cut off from civilization by a heavy snowfall. What he described really had little relation to the conditions that existed in the Age of Homespun, but it struck a responsive chord. Americans could have the illusion of being separated in their detached houses, while all the time, perhaps invisibly, they were becoming all the more connected through transportation networks, sewer and water mains, gas lines, and later electric and telephone wires.

The reason this concept of the single family house and the life that it was supposed to embody caught on so well was that it was very flexible. Willis' Home Journal was a smart magazine, appealing to a certain type of audience. Those with more subdued tastes got essentially the same message in the more restrained magazines like Godey's Lady's Book, where Downing's plans occasionally appeared. In short stories in these magazines authors such as Sarah J. Hale, Lydia Sigourney, and Harriet Beecher Stowe continually developed the themes of living in these domestic arrangements and, concomitantly, often decried as unwholesome, other situations like rooming houses. (15)

In fact, in the first part of the nineteenth century the detached house, its objects and furnishings became a source of metaphor and imagery, a universal language that everyone was interested in and understood. It superseded in part the vocabularies of religion and farming. The number of magazines whose titles included the words "house" or "home" increased significantly, and this continued well into the present with journals like House and Home and the Lady's Home Journal. (16) It was typical, then, that Mrs. Stowe chose to epitomize the character of her hero by calling her novel Uncle Tom's Cabin. When Lincoln talked about a "house divided," there was a special ring to his phrase. Or, for that matter, it was no accident that the focus of baseball, a game developed during the Civil War, was "home."

By the Civil War the essential qualities that were to distinguish American housing for the next hundred years had been established. The home's transformation from a place of "domestic manufacture" to one merely of "residence" established an identity that involved not only architectural and environmental characteristics, but also a relationship to other emerging institutions such as libraries, factories, offices, schools, hospitals, department stores, etc. The galaxy of these facilities, when distributed in space with housing the figurative focal point, constituted a general urban form that is the basis of the modern city. Implicit in this concept of housing was the assumption that it should be the concern of a profession that claimed to have the expertise to deal with it. The task in housing, therefore, has had two aspects since the Civil War. First, there has been a continual effort to refine the idea of the environmentally-defined and activity-specific home in the light of new technical equipment and appliances. Second, ways have been sought to make this kind of home available to all citizens. A full exposition of how these themes have been played out is beyond the scope of this paper. But a few examples may elucidate the meaning of some more recent housing.

Of course not everyone could attain this ideal house. But all the literature of the day led one to believe that, even if you then did not live in the right kind of house, it was within the realm of expectation or attainment. (17) In the same volumes in which he published plans for the villas of the wealthy, Downing included workingmen's houses. Some reviewers pointed out what they thought was an element of hypocrisy in this, but many people believed that there really was, or at least could be, a connection. (18)

Friedrich Engels, writing in the mid-nineteenth century about housing reform movements, saw the acquisition of housing by the working class as an attempt to diffuse a coming revolution. According to him, "it was absolutely necessary to cut the umbilical cord which still bound the worker of the past to the land." Only when the worker was freed from all such ties and had gravitated to the big cities could this capitalist class be overthrown. He mentioned with derision miserable housing developments on the outskirts of American cities. (19)

American workers, however, flocked to this kind of housing. A recent study of one American city has convincingly shown that property ownership was one of the most available and readily seized upon means of social mobility in the United States. Few workers improved their circumstances in true Horatio Alger dimensions, but the mere fact of ownership established a connection between rich and poor that helped to knit together the social fabric. Even in depressions, few mortgages were foreclosed. It may be that making the payments put a strain on the family and forced children to forego an education that would have led to greater social mobility, but a surprising number of workmen seemed to follow this path. (20)

What Engels did not reckon on was the incredible appeal of goods and objects for those who had been accustomed to the deprivations of the Age of Homespun. The house was the biggest and most important object that the average wage earner might acquire. Ultimately, because it was a physically perceivable entity, the detached house had an alluring appeal, no matter what style it was in or how small it was, that made it desirable. It was precisely this quality, a tangible presence that went beyond questions of utility or money value, that enabled so many people at whatever level of consciousness to see the issue of housing more in the terms of a Downing than an Engels.

The connection, somewhat self-conscious, that Downing indicated by showing a workingman's cottage opposite an elaborate villa in his books may actually have been established by more than widespread property ownership. In the latter part of the nineteenth century plans and designs of housing were diffused through popular publications. A typical one appeared first in the magazine American Agriculturalist and later was published in an inexpensive book. (21) According to the construction costs quoted, it was well within the price range of those with a moderate income or even less. But the essential housing concept was flexible enough so that additions would be added later, as the family grew in size or fortune. Houses in the Boston area taken directly from this publication or by imitation show how the basic plan could be modified to become a fairly sumptuous dwelling. Sytlistically, at least, there was a tangible and perceptible connection between the detached houses of families in the range of a broad middle class.

But this affinity can also be seen in another direction that shows how even poorer people might have been included in one unifying conception of housing. It also illustrates how mass housing may have been conceived by those who built it. When families could not afford a detached house or when a high density of occupancy was demanded, single houses were often divided, one family to a floor. This was a simple adjustment that was often made in the basic house type mentioned above. Since this house had a staircase on one wall, two such houses were often joined side to side to economize on open space and get a more compact design. If the two room, front and back plan was kept, it could be extended continually down a block in a row house fashion, often four stories high. Eventually corridors and stairs, which in these cases served only several families, were centralized and early examples of what came to be apartment blocks developed. Another tendency was for extra rooms to be added onto the back of the basic plan to fill out the lot. In Boston this led to the three decker railroad apartment building that proliferated side by side, leaving the narrowest breathing spaces between structures.

Group housing was conceived in terms of concepts that were distilled from single family housing. Taken together as a comparison, the single family detached house and the multiple dwelling seem to have little in common, but, when illustrated by this sequence of half steps, it becomes clear how an idea of a domestic living environment was transformed. In the extreme case of the multiple dwelling a decorative mansard roof might carry over the identity, but this was merely in the architect's imagination, because the essential qualities of the single family house had been compromised out of existence.

This way of thinking about mass housing is important because it figured in the formulation of the minimum property standards of the Public Housing Administration and the Federal Housing Administration. Much of the thinking that led to the enactment of these programs in the New Deal was done by a Presidential Housing Conference in 1932. They produced an eleven volume report that was the most comprehensive study of housing done in this century. (22) In formulating minimum standards for housing, they went through in an abbreviated fashion the process that was outlined above. They did astudy to extract the essential qualities of selected examples of existing moderately-priced single family dwellings. This data was expressed in minimum dimensions and suggested furniture layouts for living room, dining room, kitchen, bathroom, and bedroom, and became the basis for all the apartments in federally subsidized housing. (23)

The perceived image of the single family house in the massive projects that were built in the last decades is even more remote than it was in the examples shown from Boston. Besides, from the point of view of performance, the apartments did not have the capabilities of the detached houses. Certain spaces, especially for play, relaxation and storage, were omitted, and others were diluted. Backyards became balconies, which, although abstractly an "outdoor space," were too small to accommodate most outdoor activities. Similarly, the court yards were "open spaces," but they were uncontrollable and had none of the personal qualities of back yards. A corridor in an apartment block could be labelled an "interior street," but this hopeful designation and the renderings showing children happily playing there did not prevent it from becoming a dangerous no-man's-land. Inside the apartment bedrooms were separate, isolated areas, but they were diminished in size and their relationship to each other was such that there was little sound control for adequate privacy.

It can be argued that these projects were improvements over the conditions of existing housing. But the predisposition, basically well-intentioned, to bestow the conditions of single family houses on the disadvantaged had serious shortcomings in the long run. A more realistic appraisal of what living in groups meant, from the point of view of what happened both inside and outside the unit, might have helped to avoid some of the problems that have beset many projects.

Many of these deficiencies developed because architects tended to regard apartment houses as efficient dwellings, machines for living. In a sense they were. Residents did not have to worry about repairing a roof or painting the outside, and plumbing that served many apartments made sense economically. However, not only were the benefits of these conditions nullified by things, perhaps less apparent, that did not work in apartment blocks, but it is also possible that residents disliked the efficient features themselves. There is much evidence to indicate that people like to take the trouble to make improvements and repairs on their homes. Decorating and furnishing is considered a source of enjoyment, not available in a rented, efficient unit. These liabilities have been accentuated in housing for low and moderate income groups, but they also exist for those who are better off. No viabble way of living in mass housing has been articulated for them either, and in the prosperous periods of the twentieth century they have flocked to detached houses on the outskirts of American cities. (24)

In the first decades of this century the concept of the single family detached house maintained its prominence in the public eye but shifted its nature. Earlier men like Bushnell, Downing, and Willis had advocated the concept directly or indirectly, for health and moral reasons. Underlying all their arguments about good taste and their instructions about the care of objects and furnishings,was an assumption of thrift and moderation. They were continually upset by what they considered the showy or vulgar extravagances of the uneducated public. It often seemed that they were fighting a losing battle. By the twentieth century this was even more the case because they were competing with increasingly vociferous voices that actively contradicted the message of moderation.

In the last few decades the single family detached house has developed into a complex structure, supplied by gas and electric lines and serviced by numerous appliances. Salesmen interested in promoting their goods have, therefore, espoused the single family detached house because it is that form of habitation that permits the maximum use of utilities, mass-produced goods, and, of course, cars. In short, the single family detached house from the 1930's on has been the residence of the consumer and in the process the basis in thrift and moderation has been completely lost.

Magazine's like McCall's published plans of houses that were furnished free to builders on the hope of gaining advertising from companies dealing in household goods. (25) General Electric sponsored a competition that received 2040 entries for model homes. These entries had to include drawings with a key to all General Electric products in the house. (26) A similar competition was run by the gas industry. In 1937 fifteen homes called "Town of Tomorrow" were displayed at the New York's World Fair. (27) Sponsored by companies like Nash-Kelvinator, Douglas Fir Plywood, and Pittsburgh Plate Glass, these companies offered nothing strikingly new or innovative. Instead their proposals embodied the immediate acquisitive dreams of the average American during the Depression. (28)

No more revealing document of this motivation exists than a series of pamphlets put out by Revere Copper during the Second World War. (29) A number of prominent architects were asked to set forth their ideas of what types of housing would be available and desirable after the deprivations of war had ended. Almost all the responses were conceived as containers for the consumer goods that Americans had not yet been able to buy. In many of the renderings Revere copper pots and pans were conspicuously displayed, and in the years after the War they became, along with dishwashers and other appliances, a fixture in the image of the American kitchen. The houses shown were generally detached, "modern" in styling, but domestic along lines that were quite similar to those built in previous decades.

Architects who espoused the tenets of the modern movement were continually frustrated. A number believed in a kind of "urbanism" which the American public almost universally rejected. The body of ideas subsumed under that word did not offer an adequate context for the consumer goods that so many people wanted in their homes. But those who espoused the trend toward suburbanization, like Frank Lloyd Wright, were also disappointed because the houses that were built were seen as commodities, not the props for a spiritual revival. The study by McCall's magazine reveals what happened to modern architecture in America. The single family house was able to encompass the movement, just as it had every other architectural style in the previous hundred years. "Modern" features were different from "Tudor" or "Cape Cod," but similar in that they represented just another set of options that decorated the same package. (30)

Attempts to eschew the therapeutic or moral qualities of environments and instead, to assess users' "needs," so popular at this moment, may not be a way out of this dilemma that has continually beset architects. When, as recently, New York City transit workers ask for a thirty-hour, four-day week with retirement possible at age fifty after twenty years of service, then we may be entering a new period of societal development which, ultimately, could be as profound in its implications as the transition from the Age of Homespun to a modern society was.

Perhaps it is not popular to talk about leisure at a time when there seem to be so many pressing social issues, but it may be that these problems can only be solved in a context of ideas that acknowledges that work is no longer the organizing principle of American life. "Leisure," in this sense is an inadequate word. Webster's Third International Dictionary defines the word as "free time as a result of temporary exemption drom work or duties." But, in the future, which for more and more people is already here, work will be the respite from leisure.

Such a state has been the goal of many philosophies, but there has been remarkably little discussion of what everyday life will be like under these circumstances. Those who conceive of it as a state of unlimited happiness and, therefore, dismiss its possibility as unlikely might consider the sobering words of John Maynard Keynes written in 1930, a time much more fraught with uncertainties than our own: "I think with dread of the readjustments of the habits and instincts of the ordinary man, bred into him for countless generations, which he may be asked to discard within a few decades....Must we not expect a general 'nervous breakdown'? We already have a little experience of what I mean--a nervous breakdown which is already common enough in England and the United States amongst the women of the well-to-do classes, unfortunate women, many of them, who have been deprived by their wealth of their traditional occupations--who cannot find it sufficiently amusing, when deprived of the spur of economic necessity, to cook and clean and mend, yet are quite unable to find anything more amusing.--To those who sweat for their daily bread leisure is a longed-for sweet--until they get it." (31)

In the light of this prospect the bases of all our social institutions, housing included, should be reexamined in an effort to make the "readjustments" as painless as possible. This is not the occasion to start this speculation, but a few concluding words are in order.

It would be a serious mistake to think that leisure, in the sense that Keynes spoke of it, could be accommodated in the home by adding another room, an expanded version of the "family room," for instance, onto the existing structure. In the same fashion, adding more facilities for relaxation to the galaxy of places which encircle the home and act as the basis of the contemporary city would be similarly short-sighted. Nor will it be profitable to think of a tri-location (city for business, home for living, country home for leisure) as a solution.

What may be possible, if not necessary, is a complete redefinition of our concept of a "planned environment" at the scale of the home and our attitude toward "place" in a broader sphere. Ultimately the detached house may still prevail as a common building type, but its content is likely to be as different as that of the farm house in the Age of Homespun was from any house built in the last decade.

Notes

1). The President's Committee on Urban Housing, A Decent Home (Washington, 1969).

2). The scope of this transformation is dealt with in: Karl Polanyi, The Great Transformation (Boston, 1957). The book covers events in England, but it has implications for any industrializing country.

3). Horace Bushnell, "The Age of Homespun," Litchfield County Centennial Celebration (Hartford, 1851), P. 105-130.

4). Bushnell, "The Age of Homespun," p. 110, 112.

5). Horace Bushnell, "The Organic Unity of the Family," Christian Nurture (New York, 1861), p. 106.

6). Citizen's Association of New York, Report of the Council of Hygiene and Public Health upon the Sanitary Condition of the City (New York, 1865), p. 258.

7). Catherine Beecher, Treatise on Domestic Economy (Boston, 1842).

8). Sigfried Giedion, Space,Time and Architecture (Cambridge, 1952), p. 280-289. Walker Field, A Reexamination Into the Invention of the Balloon Frame (unpublished thesis, Harvard College, 1948).

9). Catherine Beecher, Miss Beecher's Domestic Receipt Book (New York, 1850), p. 249.

10). Arthur Meir Schlesinger, Learning How To Behave (New York, 1946).

11). Citizen's Association, Report, p. 30-31, 56-57, 288-289.

12). A typical comment is found in: Nathaniel Parker Willis, *Out-Doors at Idlewild* (New York, 1855), P. 213. "Downing's genius was our country's one solitary promise of a supply for this lack of common currency--this scarcity of beauty coin in our every-day pockets.

See also: Frederika Bremmer, *Homes of the New World* (New York, 1859), vol. 1, p. 13-51.

13). Willis, *Out-Doors*, p. 194.

14). Edward Everett Hale, *Workingmen's Homes* (Cambridge, 1874).

Sam B. Warner, Jr., *Streetcar Suburbs* (Cambridge, 1962).

15). A good example of this kind of literature is: Harriet Beecher Stowe, *House and Home Papers* (Boston, 1865).

16). Frank Luther Mott, *A History of American Magazines* (New York, 1930, 1938), vol. 1, p. 365-366; vol. 2, p. 56-59, 349, 355.

17). Excellent examples of this kind of writing can be found in: ------, *Homes of American Authors* (New York, 1853). and: ------, *Homes of American Statesmen* (Hartford, 1855).

18). ------, "Downing's Country Residences," *American Agriculturalist*, vol. IX, Dec. 1850, p. 381.

19). Friedrich Engels, *The Housing Question* (New York, 1935), p. 28, 35.

20). Stephan Thernstrom, *Poverty and Progress* (Cambridge, 1964).

21). Samuel B. Reed, *House Plans for Everyone* (New York, 1878), p. 44-49, 76-81.

22). John Gries and James Ford, General Editors, *Publications of the President's Conference on Home Building and Home Ownership* (Washington, 1932).

23). Gries and Ford, *Publications*, vol. IX, p. 172-183. vol. X, p. 103-118, 126-127.

24). The state of another form of housing can be understood in: ------, "Apartment Hotels in New York City," *Architectural* Record, vol. XIII, Jan. 1913, p. 85-91.

25). ------, "Publicizing the Model House," *Architectural Forum*, Dec. 1937, p. 525.

26). ------, "Publicizing the Model House," *Architectural Forum*, Dec. 1937, p. 523, 525.

27). ------, "Fifteen New York World's Fair Houses," *American Builder*, June, 1939, p. 15.

28). Some of the pressures for selling houses at this time are mentioned in: John P. Dean, *Home Ownership: Is It Sound?* (New York, 1945).

29). ------, "Revere's Part in Better Living," nos. 1-25, 1944.

30). Frank LLoyd Wright, *The Disappearing City* (New York, 1932).

McCall Corporation, *The American Woman's Home of Tomorrow* (New York, 1945).

William Jordy, "The Aftermath of the Bauhaus in America: Gropius, Mies, and Breuer," *Perspectives in American History*, vol. 2, p. 485-543.

31). J.M. Keynes, "Economic Possibilities for our Grandchildren," 1930.

IMAGINATIVE MODES OF PERCEIVING THE CITY: THE ARCHITECTURAL METAPHOR IN TWENTIETH CENTURY AMERICAN LITERATURE

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The city is so inescapable a part of present-day American life that the idea of the city, and not merely its presence, engages us all. Writers, too, have found in the city a subject for their art, and the 20th Century is rich in literature that has grown out of their imaginative responses. Ben Hecht's journalist in 1001 Afternoons in Chicago surely reflects the desire of many writers when he thinks of the ideal city novel, one that would definitively render its subject: "The city is so and so. Everyone feels this and this. No matter who they are or where they live, or what their jobs are they can't escape the mark of the city that is on them." (1) To express the desire is to realize at once the impossibility of ever fulfilling it precisely because few could agree on the nature of the "so and so" or the emotional content of the "this and this" or the shape that the "mark of the city" should take.

Although there is no one clear response to the city, one can discover a pattern in the variety of responses that the city has evoked in many American writers. The major imaginative modes that shape the response to the city are the romantic, the social, and the moral. Certainly these imaginative perceptions of the city are not as separate as such a listing makes them appear; rather they exist simultaneously in the work of any writer dealing with the city. But I believe that usually one or the other of such imaginative modes dominates, and thus shapes, a writer's response to the city. It is, unfortunately, much easier to classify such imaginative modes than it is to define them or to say, with any exactness, what the distinguishing elements of each mode are. What follows, then, is a tentative formulation of the identifiable aspects of each mode.

The romantic imagination's response to the city is, primarily, awe. A sense of awe informs the romantic writer's attempt to express what is for him essentially ineffable. I believe that basic to the romantic mode is the sense of the city as a monolithic force. The force may be personalized as we see it, for example, in Carl Sanburg's "Chicago":

> Come and show me another city with lifted
>   head singing so proud to be alive and
>   coarse and strong and cunning.
> Flinging magnetic curses amid the toil of
>   piling job on job, here is a tall bold
>   slugger set vivid against the little
>   soft cities;
> Fierce as a dog with tongue lapping for
>   action, cunning as a savage pitted
>   against the wilderness,
>   Bareheaded,
>   Shoveling,
>   Wrecking,
>   Planning,
>   Building, breaking, rebuilding,
> Under the smoke, dust all over his mouth,
>   laughing with white teeth,
> Under the terrible burden of destiny
>   laughing as a young man laughs,
> Laughing even as an ignorant fighter
>   laughs who has never lost a battle,
> Bragging and laughing that under his
>   wrist is the pulse, and under his ribs
>   the heart of the people,
> Laughing!
> Laughing the stormy, husky, brawling
>   laughter of Youth, half-naked, sweating,
>   proud to be Hog Butcher, Tool Maker,
>   Stacker of Wheat, Player with Railroads
>   and Freight Handler to the Nation.

Or the force may be likened to some large feature of nature. The jungle, for example, is a metaphor frequently used to emphasize the cunning and complexity of the urban entity and, especially, to emphasize the animalistic behavior that the observer may find in city life. Upton Sinclair, for example, entitled his novelistic exposé of the Chicago meat-packing industry The Jungle. More recently, Evan Hunter's The Blackboard Jungle exposes the problems besetting a big city slum school. The metaphor has been picked up by Hollywood, too, in a 1950 film called "The Asphalt Jungle." In addition to the jungle, the ocean is another feature of nature metaphorically employed to suggest the force of the city, often resulting in such characterizations as individuals being "adrift" in the city or "swept along by the tide" of city life. The romantic perception of the city as force often leads to the imaginative view that the city has a life of its own, quite independent of the lives of its inhabitants. This view, in turn, leads to the conceptualization of the city as a giant of steel and concrete which dwarfs the individual human being.

The origins of the idea of the city as force are so diverse as to defy any single explanation, but I believe that the romantic mode of perception is most fully operative in two distinct groups of writers. One group includes those who arrive in the city for the first time as young men and women, having spent their childhoods in rural or small-town surroundings. The work of this group--of whom Theodore Dreiser is a splendid example--begins to appear with real frequency in the early years of this century during the great urbanization of America. The second group is constituted of those writers who, though they may be from birth native to the city, are limited, usually by poverty or race--and often both--to their immediate neighborhood, at least during their formative years. In the case of either group their imagination is likely to focus on the lower classes--that is to say, poor and often exploited people.

Finally, because the romantic mode of perception does see the city as force, the architectural metaphor informing the work of romantic writers (of the sort I mention) is likely to stress sheer size, rather than minute detail, and to concentrate on the city's ability to dehumanize the smaller human entity.

The social imagination apprehends the city not as a force but rather as an intricate network of social groupings. The physical city itself appears as the outward manifestation of the financial power and social aspiration of the various groupings that inhabit it. In works in which the social mode of perception dominates, there is likely to be close scrutiny of social class and a firm understanding of social distinction. And such works are likely to concern themselves primarily, though not exclusively, with the moneyed class and socially well established because it is in such groupings as these that the social imagination finds the shadings and nuances of meaning necessary to the functioning of this mode of perception.

A phrase in Henry James's Washington Square serves as an admirable distillation of what the social imagination requires. Speaking of Washington Square as it appeared in 1835 and the immediate area of Fifth Avenue, James remarks: "It has a kind of established repose which is not of frequent occurrence in other quarters of the long, shrill city; it has a riper, richer, more honorable look than any of the upper ramifications of the great longitudinal thoroughfare--the look of having had something of a social history." (2) With its emphasis on richness and ripeness and honorableness, James's description not only distills the sense of the social mode of perception, it also points toward the difficulty that writers possessing the social imagination have had in dealing with the American city. Consider the following passage from Edith Wharton's The Custom of the Country in which a French nobleman upbraids his parvenu American wife for her utter lack of sensitivity to the value of tradition:

> "You come among us from a country we don't know, and can't imagine, a country you care for so little that before you've been a day in ours you've forgotten the very house you were born in--if it wasn't torn down before you knew it! You come . . . from hotels as big as towns, and from towns as flimsy as paper, where the streets haven't had time to be named, and the buildings are demolished before they're dry, and the people are as proud of changing as we are of holding to what we have." (3)

Although he is addressing only his wife, the character's remarks are so generalized as to include all Americans. Clearly, the rapidity of change in American city life militates against the social mode of perception, for many areas of our cities are not in existence long enough to develop, in James's sense and phrase, "the look of having had something of a social history." Because of their particular vision of the city, writers whose mode of perception is primarily social stress the significance of architecture, especially domestic architecture, seeing it as the objectification of social refinement and attainment.

Finally, the moral mode of perception views the city in two wildly disparate ways. To one aspect of the moral imagination the city may--and historically, in imaginative terms at least, certainly did--appear as a mecca of moral freedom where one might escape from the stifling conventions that have been so closely associated with American small town life. Having escaped from the crippling inhibitions of the small town, the fictional hero is enabled to develop his full potential in the freer atmosphere of the city. This view of the city is clearly the stuff out of which dreams are made, promising the fulfillment of the proverbial American legend--"Small Town Boy Makes Good." Imaginatively, the city has been that place where one may rise in the world. Although declining in importance, this version of the moral imagination's response to the city still persists. But the morally affirmative view of the city is more clearly present in current non-fiction than it is in current fiction. Two outstanding examples are Harvey Cox's phenomenally successful theological work, The Secular City, published in 1964, and Reyner Banham's Los Angeles: The Architecture of Four Ecologies, published in 1971. It is, however, the moral mode's other vision of the city which has dominated the literary scene for years, and its influence continues to grow. To this aspect of the moral imagination the city appears as the distillation of chaos, the arena of radical alienation and free-floating violence and hostility. Played out against the backdrop of a chaotic urban scene, human life becomes increasingly difficult, progressively disjunctive, frighteningly empty, ultimately meaningless. Act is separated from consequence, life divorced from value. This aspect of the moral imagination, then, sees the city not as that place where dreams are fulfilled but rather where nightmares are lived out. In its more extreme forms, the cityscape as perceived by this imaginative mode takes on surrealistic hues, and the architecture is made to reflect the chaotic uncertainty of the people's lives.

In the following brief discussion I hope to illustrate the way in which a particular mode of perception operates to shape a writer's view of the city. The discussion moves from the romantic to the social to the moral. I have devoted the most space to the despairing aspect of the moral mode of perception because, to repeat, it dominates current fiction.

Theodore Dreiser is exemplary of a whole group writers who around the turn of the century gravitated to New York or Chicago from their small town homes. Sister Carrie, published in 1900, is his first and perhaps his most important work. In many significant ways it is a thinly disguised autobiography of his spiritual and emotional tumult resulting from his move to Chicago. The opening chapter of Sister Carrie, sees Dreiser investing Chicago with the attributes characteristic of the romantic mode of perception. The chapter itself is entitled "The Magnet Attracting: A Waif Amid Forces." Chicago is, of course, the magnet, Carrie the waif, and the "cunning wiles" of the city are the forces. Dreiser repeatedly employs the image of the magnet to suggest Chicago's attraction; once caught in its field of force, the individual cannot extricate himself and is drawn, powerless, into its center. Dreiser also employs metaphors from nature to suggest the same meaning. The city is likened to an ocean, literally engulfing the individual. On her arrival in Chicago, for example, Carrie is "a lone figure in a tossing thoughtless sea." (4)

The ability to survive in such an environment, Dreiser suggests, does not really rest with the individual; rather survival, and in Carrie's case success, is more a matter of luck than it is anything else. Carrie's own success results directly from her ability to ride the crest of the wave in that "tossing thoughtless sea" in which she finds herself. Dreiser's choice of career for Carrie is symbolic, for by making her a successful actress he stresses her adeptness at role-playing, an ability which, Dreiser seems to suggest, makes for success in real life as well as in the fictional life of drama. The major point, however, is that Carrie does not shape her own success. She is simply subject to the forces in the city that mysteriously lift her to fame and fortune.

As if to underscore the futility of human endeavor, Dreiser includes a character named Hurstwood whose career is the direct opposite of Carrie's. At his first appearance in the novel, Hurstwood seems to have attained at least a modest degree of success. But as Carrie's fortunes rise, Hurstwood's decline. The trajectory of that decline is charted through reference to the city as force. When Hurstwood and Carrie leave Chicago for New York, Dreiser comments on the significance of that move for Hurstwood in the following terms: "Whatever a man like Hurstwood could be in Chicago, it is very evident that he would be but an inconspicuous drop in an ocean like New York. . . .The sea was already full of whales. A common fish must needs disappear wholly from view--remain unseen. In other words, Hurstwood was nothing." (5) We see again in this language the evocation of the city as the ocean; the human beings who inhabit it are merely fish--some swim and some sink. The human individual is engulfed by the larger entity, the city. Hurstwood's eventual suicide comes as no surprise; it is simply the end result of forces beyond the control of Hurstwood or any other individual.

As might be expected in such a romantic view of the city as force, the actual architectural metaphor is blurred. In architectural terms, there is little that is clearly individualized. Only the city itself emerges as a monolith which dwarfs the individual.

Like all things romantic, the romantic perception of the city is difficult to sustain. In his autobiography Dawn, Dreiser recalls the wonder he felt when, as a young man from a small town, he first experienced Chicago:

> The city of which I am now about to write never was on land or sea; or if it appears to have the outlines of reality, they are but shadow to the glory that was in my own mind. Compassed by a shell or skull, there was a mirror inside me which colored

> all it reflected. There was some mulch of chemistry that transmuted walls of yellow brick and streets of cedar block and horses and men into amethyst and gold and silver and pegasi and archangels of flaming light. There was a lute or harp which sang as the wind sings. The city of which I sing was not of land or sea or any time or place. Look for it in vain! I can scarcely find it in my own soul now. (6)

One cannot fail to notice the nostalgia which characterizes Dreiser's remembrance. The same nostalgic tone is present also in F. Scott Fitzgerald's "My Lost City." Although a far different kind of novelist than Dreiser, Fitzgerald is dealing with precisely the same sort of romantic perception of the city that characterizes Dreiser's work. Fitzgerald speaks here of viewing New York from the Plaza Roof of the Empire State Building. From this perspective he

> discovered the crowning error of the city, its Pandora's box. Full of vaunting pride the New Yorker had climbed here and seen with dismay what he had never suspected, that the city was not the endless succession of canyons that he had supposed but that it had limits. . . And with the awful realization that New York was a city after all and not a universe, the whole shining edifice that he had reared in his imagination came crashing to the ground. (7)

Of American writers whose view of the city is shaped by the social mode of perception, none is more deserving of notice than Edith Wharton, who came from a family who traced its heritage to old Knickerbocker New York. Her main subject as a novelist was the impact of the newly rich on the socially established of New York. In many ways her novels deal with the conflict between those with cash and those with culture.

Her major way of objectifying this conflict was through reference to architecture. The side of culture and tradition, and all the virtues she saw invested in a hierarchically structured class society, she represents through the use of what may be called an organic architecture. The houses, for example, in her novels are in fact simply an extension of their owners' personalities. In The Custom of the Country we see her employing the architectural metaphor to distinguish what is socially worthwhile from what she deemed was not socially acceptable. The passage here concerns one character's recognition of the essential "rightness" of old New York's social view. As he returns to his grandfather's house in Washington Square, he realizes that the house itself is symbolic of the "outward form" of his family's life-style. Contrasting to the emblematic organic unity of the house in Washington Square are the elaborate houses of the newly rich, emblematic of "the social disintegration expressed by widely-different architectural physiognomies at the other end of Fifth Avenue." He concludes that what was

> called society was really just like the houses it lived in: a muddle of misapplied ornament over a thin steel shell of utility. The steel shell was built up in Wall Street, the social trimmings were hastily added in Fifth Avenue; and the union between them was. . .monstrous and factitious. (8)

The interplay that the passage develops is one of conflicting life-styles. The Washington Square house represents social coherence and moderation; the Fifth Avenue mansions stand for social disintegration and excess. The Washington Square house embodies its owners' interior lives; the Fifth Avenue mansions, with their expensive facades supported by steel skeletons, suggest that their owners have no interior lives. The Washington Square house is the distillation of a slowly evolved tradition; the Fifth Avenue mansions are simply the manufactured products of quickly accumulated wealth. But as might be expected, the social conflict represented by the differing architectural styles must be resolved in favor of those with the greatest amount of money.

Edith Wharton's work, then, suggests the difficulty that the novelist whose perception of the city is primarily social has always faced in this country. The social mobility that wealth, however gained, has always brought with it is in itself an obstacle to developing the kind of milieu necessary for such a novelist as Edith Wharton. Additionally, the rapid change in neighborhood patterns in city life further militates against any growth of social history. The latter point reaches an extreme in such a book as Future Shock which finds Alvin Toffler speculating on the extension of the concept of a "throw-away culture" not merely to given architectural structures but to "an entire urban agglomeration freed of fixed position, floating on a cushion of air, powered by nuclear energy, and changing its inner shape even more rapidly than New York does today." (9)

The kind of cultural dislocation that Toffler suggests is symptomatic of "future shock" may very well be operative in one of the most powerful evocations of the moral mode's despairing vision of the city, Nathanael West's The Day of The Locust, published in

1939. In his own lifetime West failed to attract any audience beyond that of a few literary critics and fellow authors, and he was forced to turn to writing screenplays for Hollywood during the last five years of his life. Out of the Hollywood years comes The Day of the Locust. In the novel, the main character, Tod Hackett, is a painter who has been brought by a "talent scout for National Films . . . to the Coast after seeing some of his drawings in an exhibit of undergraduate work at the Yale School of Fine Arts." (10) Like his creator, Tod uses his artistic abilities to support himself by working for the movies, in his case, set and costume designing. But he focuses his real creative energies on a huge canvas of his own to be called "The Burning of Los Angeles." He conceives the idea for the work during evening walks. Surveying the varieties of people with a painter's eye, he observes two distinct groups. One group is comprised of masqueraders: "The fat lady in the yatching cap was going shopping, not boating; the man in the Norfolk jacket and Tyrolean hat was returning, not from a mountain, but an insurance office; and the girl in slacks and sneaks with a bandana around her head had just left a switchboard, not a tennis court." But in the second group are "people of a different type. Their clothing was sombre and badly cut, brought from mail-order houses . . . . they loitered on the corners . . . and stared at everyone who passed. When their stare was returned, their eyes filled with hatred. At this time Tod knew very little about them except that they had come to California to die." He knows, too, that he must paint them, but "despite his race, training and heritage, neither Winslow Homer nor Thomas Ryder could be his masters and he turned to Goya and Daumier." (11)

Through the groups of people that Tod sees West suggests a radical separation between fantasy and reality. The masqueraders are able, at least partially, to live out their fantasy. The others, those of the shabby mail-order clothes, are not. Though unable to fulfill the fantasy in their style, they share it in their spirit. Deprived of dream fulfillment, they are instead filled with hate. In effect what West suggests is that Hollywood, so often likened to a Dream Factory, has raised the level of expectation to such fantasy heights that failure to attain the expectation of the manufactured dream will lead progressively from boredom to hatred to violence. The implication is clear: with the denial of the dream, Los Angeles will burn.

After establishing the importance of--and potential danger in--the fantasy shaping the lives of the people, West turns immediately to architecture to reinforce the chaos of dream turned nightmare:

> not even the soft wash of dusk could help the houses. Only dynamite would be of any use against the Mexican ranch houses, Samoan huts, Mediterranean villas, Egyptian and Japanese temples, Swiss chalets, Tudor cottages, and every possible combination of these styles that lined the slopes of the canyon.
>
> When he noticed that they were all of plaster, lath and paper, he was charitable and blamed their shape on the materials used. Steel, stone and brick curb a builder's fancy a little, forcing him to distribute his stresses and weights and to keep his corners plumb, but plaster and paper know no law, not even that of gravity.
>
> On the corner of La Huerta Road was a minature Rhine castle with tarpaper turrets pierced for archers. Next to it was a highly colored shack with domes and minarets out of the Arabian Nights. . . . Both houses were comic, but he didn't laugh. . . .
>
> It is hard to laugh at the need for beauty and romance, no matter how tasteless, even horrible, the results of that are. But it is easy to sigh. Few things are sadder than the truly monstrous. (12)

To the eye of the architect, these styles may mean something quite different from what they do to the moralist, and West was surely a moralist. He does not intend us to see this mélange of architectural styles as expressive of meaningful cultural diversity but rather of cultural confusion. Very literally, the architecture here is a projection of the celluloid dream beyond the screen and into the lives of the people. We see West's point unmistakably when he describes Tod's walk across National Film's production lot. Headed toward a set shooting an epic appropriately called "Waterloo," he confronts a mishmash of fantasy and reality: "an ocean liner made of painted canvas with real life boats hanging from its davits"; a fake desert with real sand presided over by "a great forty-foot papier mâché sphinx." He passes through the swinging doors of the "Last Chance Saloon" and steps onto a Paris street which ends in a Romanesque courtyard. "He pushed his way through a tangle of briars, . . . skirting the skeleton of a Zeppelin, a bamboo stockade, and adobe fort, the wooden horse of Troy, a flight of baroque palace stairs that started in a bed of weeds and ended against the branches of an oak, part of the Fourteenth Street elevated station, a Dutch windmill, the bones of a dinosaur, the upper half of the Merrimac, a corner of a

Mayan temple, until he finally reached the road." He thinks of the studio lot as a kind Sargasso Sea of the imagination, a dream dump which "grew continually, for there wasn't a dream afloat somewhere which wouldn't sooner or later turn up on it . . . [to be] reproduced on the lot." (13)

And the dream is all-engulfing, from the successful and wealthy, like Tod's friend, Claude Estee, to the socially rejected and poor, like Homer Simpson, another of Tod's friends. Again the pervasiveness of the dream realizes itself in architectural metaphor. Estee, "a dried-up little man," lives in "an exact reproduction of the old Dupuy mansion near Biloxi, Mississippi" and plays out his life in the role of a Southern gentleman, "an impersonation that went with the Southern colonial architecture." (14) Homer Simpson's "Irish" house in Pinyon Canyon strives in its own way for the authenticity of reproduction that Estee's house illustrates. The door, for example, "was of gumwood painted like fumed oak and it hung on enormous hinges. Although made by machine, the hinges had been carefully stamped to appear hand-forged. The same kind of care and skill had been used to make the roof thatching, which was not really straw but heavy fireproof paper colored and ribbed to look like straw." (15) What we see, then, is the same blurring of fantasy and reality that marks the studio lot.

Everywhere he goes, Tod finds new material for his painting and confirmation of his vision for its subject matter. From the female impersonators at the Cinderella Bar, "a little stucco building in the shape of a lady's slipper," to the various cultist temples that he visits, Tod finds such things that engage his compassion as a human being and his imagination as an artist. He decides that his painting will "show the city burning at high noon, so that the flames would have to compete with the desert sun and thereby appear less fearful, more like bright flags flying from roofs and windows than a terrible holocaust. He wanted the city to have quite a gala air as it burned, to appear almost gay. And the people who set it on fire would be a holiday crowd." (16)

The novel ends with what we are to take as the overture to the fulfillment of Tod's vision. A huge crowd gathers below "the rose-colored domes and delicate minarets of Kahn's Persion Palace Theatre" (presumably a take-off on Grauman's Chinese). They are there for a world premiere so that they can see the stars arrive, but Tod realizes they are not mere "harmless curiosity seekers. They were savage and bitter, especially the middle-aged and old, and they had been made so by boredom and disappointment." (17) These are the people who have slaved their lives away to save the money to come to California to live out the dream in the place of its making. (It is not for nothing that West calls the studio for which Tod works National Films.) Their lives are vicarious; they long for something--anything--to give them meaning. An incident sets off a riot; the rioters are happy--at last something, at last release. The novel collapses in a hysteria of laughter and screams and sirens.

For a generation whose memory and imagination have been seared by Watts, Detroit, Newark, West's vision has proved disastrously prophetic. We have learned that cities are highly combustible. West's fiction tells us what history teaches us: violence is not casually related to boredom; it is the end product of boredom. The novel also proves that the old axiom about society getting the kind of art it deserves is reversible: art gets the society it deserves. For at the center of The Day of the Locust is the insistence that falseness in art will corrupt and falsify life itself. Through the architectural metaphor as an objectification of the celluloid dream, West manages to suggest a moral bankruptcy at the center of the dream. His work, therefore, points toward national calamity arising from national recognition that the American Dream of success and fulfillment no longer means anything more than the grotesque parody that Hollywood provided. At that recognition Tod envisages chaos: "The Angelenos would be first, but their comrades all over the country would follow. There would be civil war." (18)

At the end of his excellent study, Reyner Banham makes the following assertion: "If Los Angeles is one of the world's leading cities in architecture, then it is because it is a sympathetic ecology for architectural design, and it behoves [sic] the world's architects to find out why." (19) But if Nathanael West's use of the architectural metaphor is correct, it behooves us all to find out why.

Notes

[1] Hecht, Ben. *1001 Afternoons in Chicago* (New York: Covici-Friede, 1922), page 286.

[2] James, Henry. *Washington Square* (New York: Dell Publishing Company, 1959), page 26.

[3] Wharton, Edith. *The Custom of the Country* (New York: Scribners, 1913), page 545.

[4] Dreiser, Theodore. *Sister Carrie* (New York: Doubleday, Page and Company, 1900), page 11.

[5] Dreiser, Theodore. *Sister Carrie* (New York: Doubleday, Page and Company, 1900), page 321.

[6] Dreiser, Theodore. *Dawn* (New York: Horace Liveright, Incorporated, 1931), page 156.

[7] Fitzgerald, F. Scott. "My Lost City" in *The City: American Experience*, edited by Trachtenberg, Neill, and Bunnell (New York: Oxford University Press, 1971), page 149.

[8] Wharton, Edith. *The Custom of the Country* (New York: Scribners, 1913), page 73.

[9] Toffler, Alvin. *Future Shock* (New York: Bantam Books, Incorporated, 1971), page 63.

[10] West, Nathanael. *Miss Lonelyhearts and The Day of the Locust* (New York: New Directions Publishing Corporation, 1969), page 60.

[11] West, Nathanael. *Miss Lonelyhearts and The Day of the Locust* (New York: New Directions Publishing Corporation, 1969), page 60.

[12] West, Nathanael. *Miss Lonelyhearts and The Day of the Locust* (New York: New Directions Publishing Corporation, 1969), page 61.

[13] West, Nathanael. *Miss Lonelyhearts and The Day of the Locust* (New York: New Directions Publishing Corporation, 1969), pages 131-32.

[14] West, Nathanael. *Miss Lonelyhearts and The Day of the Locust* (New York: New Directions Publishing Corporation, 1969), page 68.

[15] West, Nathanael. *Miss Lonelyhearts and The Day of the Locust* (New York: New Directions Publishing Corporation, 1969), pages 80-81.

[16] West, Nathanael. *Miss Lonelyhearts and The Day of the Locust* (New York: New Directions Publishing Corporation, 1969), page 118.

[17] West, Nathanael. *Miss Lonelyhearts and The Day of the Locust* (New York: New Directions Publishing Corporation, 1969), page 177.

[18] West, Nathanael. *Miss Lonelyhearts and The Day of the Locust* (New York: New Directions Publishing Corporation, 1969), page 118.

[19] Banham, Reyner. *Los Angeles: The Architecture of Four Ecologies* (New York: Harper and Row, 1971), page 244.

SHOULD THE SUBURBS PLEAD GUILTY?

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I

In 1968, the Kerner Commission served notice on the American nation that we were "moving toward two societies, one black, one white--separate and unequal": one society impoverished, disadvantaged, lower-class, and black; the other well-off, educated, middle-class, and white.(1) What the Commission did not observe is that each of these societies has its own geographical *locus*--the black, poverty-striken one principally in the cities, the white, well-to-do one almost entirely in the suburbs of the United States. Nothing that has happened since 1968 has alleviated the division the Kerner Commission warned against; the evidence is all the other way 'round. Suburban population has become still more preponderantly white, city population still more markedly black: "During most of the 1960's," analysis of census data reveals, "90 percent of the non-white population gain took place in the cities, whereas 100 percent of the white population gain took place in the suburbs."(2)

If it is not arrested, this trend could lead ultimately to largely-black economically deprived cities surrounded by rings of all-white, economically privileged suburbs: surely a blueprint for trouble. The next American Civil War may be fought out on this ground, not North vs. South, but the suburbs, where 75 million people now live, pitted against the cities, the home of 59 millions. Anyone who has been listening will have heard the first distant rumblings of this conflict, most of them emanating from the courts, and most of them directed against suburban *residential exclusivity*.

Item: Black Jack, Missouri, a suburb north of St. Louis, quickly incorporated to head off a church-sponsored plan to build federally subsidized low-income apartments within its borders. In its first act after incorporation, Black Jack adopted zoning that bans apartments. The case is now in the courts.

Item: Oyster Bay on Long Island is blessed with some 3,000 acres of vacant residential land and the tax revenue from an aircraft plant that employs 30,000 workers, most of whom cannot afford to live nearby. The NAACP has sued the community in an attempt to force rezoning of half of the residential land into plots smaller than the present one- and two-acre requirements and to force acceptance of garden apartments to house low-income and moderate-income employees of the plant.

Item: In Union City, California, south of Oakland, the City Council rezoned land to allow construction of low-rent apartments for relocation of the community's ghetto-dwelling Mexican-Americans. White residents circulated petitions against the proposal, brought the question to a referendum, and overturned the Council's action. Whether they had the right to do so is an issue before the courts, although in a similar case, the Supreme Court has upheld "the right of towns to keep out multi-family housing by public referendum."(3)

These suburbs, and the 95 others against whom the Department of Justice has initiated suits since 1968, are using the police power of zoning to accomplish two objectives: to keep racial minorities out, and to keep money in. The economic motivation is a strong one, for suburbs are unwilling to let low-income housing water down the benefits that have followed the exodus of middle- and upper-class taxpayers, and commercial and industrial enterprises, from the cities. The suburbs' gain has, of course, been the cities' loss. Between 1952 and 1966, for example, St. Louis lost 50,000 jobs while its suburbs gained 193,000. In the same period Philadelphia lost 14,700 jobs while its suburbs gained 249,433.(4) The pattern is similar elsewhere. The jobs are moving to the suburbs, which don't want to house the people who most desperately need the jobs. "Today for many blacks," *Ebony* comments, "It is not a case of escaping to the suburbs to get away from the crowding, the poor schools and the crime; it is a case of finding living quarters near enough to a job to keep home and family together."(5)

A still more emotional issue is that of suburban *educational exclusivity*. Most American suburbs are proud of their school systems, with reason. As compared with city schools, theirs are generally newer and cleaner on the outside, and of higher quality on the inside, where more talented teachers are paid more to teach pupils who are better prepared (if no brighter) than their counterparts in the city.

Since suburban schools are almost all white, and economically and socially homogeneous as well, it can be argued that however handsome the physical plant, however well-paid the teachers, however impressive the number of dollars expended per pupil, suburban students are still shortchanged. That is the assertion of two Columbia University researchers who showed a picture of two identically dressed boys, one Negro, one white, to first, second, and third graders in suburban schools and asked them which boy they would choose to play with. Of 235 children, 187 chose the white boy, 31 the Negro, 15 chose both, and two said they didn't want to play with either. Their teachers were astonished; they had spoken in class of the need for tolerance.(6)

But if homogeneity breeds a certain cultural deprivation, few suburban parents are willing to do away with it through merger or through pupil and teacher exchange programs with the central city schools. They have paid more for their schools, they say, and they intend their children to have the best education that money can buy. But do suburban taxpayers pay more for education? In relative terms, they do not, according to a decision of the California Supreme Court in September, 1971. As an example, the Court compared the Los Angeles County districts of Beverly Hills and Baldwin Park. During 1968-69, homeowners in Baldwin Park paid $5.48 per $100. of assessed valuation in school taxes, while homeowners in much wealthier Beverly Hills paid only $2.38 per $100. of assessed valuation. But there is so much more valuable property to be assessed in Beverly Hills that each student there received $1,231.72 "worth of education" compared with only $577.49 per student in Baldwin Park. Observing that both the taxpayers and the schoolchildren of Baldwin Park were treated inequitably, the Court ruled that basing school taxes on assessed property values was unconstitutional. This landmark case, presumably will await final disposition from the United States Supreme Court.(7) Another kind of challenge to suburban educational exclusivity has come from Richmond, from Indianapolis, and from Grand Rapids, where judges have questioned the right of suburbs to remain aloof from the school desegregation problems of central cities. In October, 1971, a federal judge in Detroit, ruling on a similar case, determined that the entire metropolitan area's schools were illegally segregated and that integration must be accomplished --if necessary, to use the dreaded word, by busing.

Much of the passionate opposition to busing is obviously racially oriented. After all, students have been taking the bus to school in many American communities for a long time now, and--especially in the South--many black children were bused across town to Jim Crow schools for years, without complaint. And how credible is the lamentation for the passing of the neighborhood school, when it comes from those who then put their youngsters on the bus to the private academies, or "seg schools," which spring into existence when it becomes clear that public school integration can no longer be forestalled?

But there are other motives, too, for the clamor against busing, which is a national and hardly an exclusively Southern or suburban phenomenon. Parents worry about the effect of long bus trips on their children. They worry still more about the kind of education their children will get in a strange, remote school. The suburbanite has a special stake in this question, for usually his child is going to a better school than is the inner-city child. Thus, while it is one thing to bring disadvantaged black youngsters out to the suburban school (many suburbs have voluntarily begun such programs), even liberal suburbanites, remembering The Blackboard Jungle, balk at sending their children to ghetto schools.

The battle over suburban exclusivity has been joined. The question is whether it can be resolved in the nation's administrative offices, legislative halls, and judicial courtrooms, or whether it will erupt into the streets of the city and the cul-de-sacs of the suburbs. If the white suburbs continue to bar the door and if conditions in the black cities continue to get worse, the fire next time is liable to spread out of control. What can be done? How can a truce be arranged before--not after --the holocaust? There is no shortage of solutions. The federal government could make the carrot tastier and the stick bigger in its present carrot-and-stick approach to integration of the two Americas. It could offer larger federal subsidies for low-income racially-mixed housing in suburbia. It could guarantee all property values in suburbs where such housing is introduced. It could deny all federal aid--including aid to education--to communities that persist in rejecing subsidized housing or school integration. The states could follow the lead of the Massachusetts law requiring localities to turn over 1.5 percent of their land to low-income housing. They could follow the lead of Hawaii and allot an equal sum of money to the education of every pupil in the state. Business could apply economic leverage to insure that suburbs welcome minority workers as residents. The suburbs themselves could initiate low-income housing and busing programs to bring substantial numbers of inner-city black children to their schools. They could do these things, but they won't: not unless there is a turnabout in the attitude of the individuals--not the federal or state or local government, but the people themselves--who live in the nation's suburbs.

II

Many who leave the city for the suburbs do so, they will tell you, in order to live relatively free of the city's harrassments--crime, drugs, racial strife, pollution, inefficiency. They have worked hard, they argue, to afford a better environment: who has the right to deny it to them? That is the way suburbanites tend to look at the issue of the two Americas, positively. The negative view is that they have given up on the cities' problems without really trying to solve them, that they have escaped their responsibilities, taken their money and run, and left the central cities, deprived of middle-class economic and political support, helpless to cope with their multiplying ills.

This dispute brings into opposition two principles that almost every American would immediately agree to. The first is that in a democracy, people may choose where they live and work and go to school. The second is that in a democracy, everyone deserves an equal chance to rise to the limit of his potential. Who will dispute the suburbanite's right to give his children a healthy living and growing environment? At the same time, who will dispute that by leaving the cities, the suburbanite has contributed to the deterioration of the urban environment which underprivileged children must inhabit? The suburbanite does what he can for his children, now. The social critic wants as much done for every child, soon, and he rightly insists that the suburbanite must cooperate to make that possible. Their goals are not dissimilar. Neither of them possesses a monopoly on virtue.

Comparison of the literature on the suburbs written during the 1950s, and that of the past five years, reveals a striking change in attitude toward suburbia. During the 1950s, most articles in high-circulation magazines expressed disapproval of the suburbs' dreary conformity, probable conservatism, excessive neighboring: they concentrated on suburban life styles, which were assumed to be new and different, as if the communities springing up from cornfields had transformed behavior while transforming nature. However, through this indictment (which I dissected and attempted to refute in a book called The Suburban Myth) ran a vein of humor; if the suburbs were conformist and homogeneous and dull, they were also at least slightly laughable. The humor was not very funny--it ran to stale jokes about the ABCs of suburbia (adultery, booze, and cookouts), to mock-serious fiction like that of Peter DeVries and Max Shulman, and eventually to Malvina Reynolds' 1963 mod folk song, "Little Boxes."

That vein of humor has now gone underground, it becomes clear in a reading of 50 articles on suburbia published by mass circulation magazines--Life, Look, Time, Newsweek, McCall's, for example--during the past five years.(8) It is almost as if the critics of the 1950s had expected the suburbs to evaporate by making fun of them. But despite the attacks and contrary to the prophecies of a massive resettlement in the cities, the nation's population has continued to flow outward. So now the voice of the social critic speaks in deadly earnest from the pages of our popular magazines.

It is a voice which discovers with alarm the tremendous political clout the suburbs are accumulating through redistricting. U.S. News and World Report announces that the suburbs are the "real gainers" through one person, one vote. Christian Century editorializes on "The Rise of Suburban Power." Time magazine proclaims "Suburbia Regnant," in command of the "new American plurality." It is a voice which tries to persuade the suburbanite of something he does not yet believe, that "the golden days are gone" and that the suburbs are "made to order for crime."(9) Above all it is a voice which chastises the suburbs for their unwillingness to share the burden of those ills that beset our central cities. During the last eighteen months, from March 1970 to September 1971, sixteen of seventeen published articles touched at least peripherally on the question of suburban exclusivity. The articles bear titles like "The Wall of Zoning," "The Moral Dilemma of Zoning," "The Suburbs Have to Open Their Gates," "Battle to Open the Suburbs: New Attack on Zoning Laws," and--most directly of all--"Snob Zoning."(10) They paint a picture of the suburbanite as callously self-seeking, snobbishly building barriers against the rights of others, incredibly insensitive to his obligations. It is a damning portrait, and the suburbanite is not likely to buy it.

Surely city and suburb must learn to cooperate; clearly, suburbanites must come to see themselves as part of what George Romney calls "the real city." But the language in which these articles are written will not contribute to cooperation. Their rhetoric is usually accusatory, often self-righteous. People have not moved from the city, they have fled or escaped or deserted. "America's cultural and intellectual high priests have located hell in suburbia so often," this from a Life magazine book review, "that one might believe they had relocated it while God slept."(11) Suburbs, it is asserted, have become "garrisons" which have slipped "a white noose" around the strangling cities; suburbanites are morally guilty for the inequities of the two Americas. The highly respected mayor of Milwaukee, in one such burst of indignation, observed that "the problems of the central city are a spectator sport to the suburban dweller who drives along the freeway between his city job and his bedroom."(12) A spectator sport? I doubt that suburbanites are really that cruel, that coolly indifferent to the misery of fellow human beings. And I am certain that the mayor of Milwaukee was unwise in attempting to fix the blame on 75 million Americans.

According to a pastor in Scarsdale, guilt "prospers in suburbia. . . . There's guilt in the business community when they feel they cannot do what they want to do as moral men. There's parental guilt when they don't have enough time for their children. They bring guilt home on the train every day."(13) Then they read an article on the train entitled "I Hate the Suburbs" and insisting that only in the cities can people "live and work . . . and show some kind of improvement as human beings."(14) On all sides, suburbanites are being made to "feel very guilty . . . without quite knowing what to do about it."(15)

By adopting the classic form of scapegoatism --blaming ills on outsiders--the social critic may purchase a temporary satisfaction. He may feel, for example, that at least he has done something. But what he has done is hardly constructive, for the language of moral indignation, directed at others, almost never leads to happy consequences. Besides, the collective implication that people in the suburbs have taken up arms or turned into latter-day Klansmen is far too sweeping, since "morally one can judge the individual only, never the group."(16)

A psychiatrist, puzzled by his unwillingness to share a sense of collective guilt for the assassination of Martin Luther King in 1968, posed the question "Am I without conscience if I cannot agree with those who call me guilty?" and answered it in the negative. It is a form of masochism, he decided, for Americans to feel guilty because they don't feel guilty. Furthermore, this kind of inappropriate guilt may lead to depression and a sense of futility. "If we are all guilty, damned, and unworthy, what of good can we possibly accomplish."(17)

One reaction to the imputation of collective guilt, then, is to accept it, hug it to our bosom, and do nothing to expiate it. Another is to deny culpability by sticking one's head in the sand. Louis Harris, in a poll conducted for Time magazine in 1970, found that over one half of the people he interviewed would not confess to living in a suburb!(18) This reaction derived partly from the census bureau's curious definition of what constitutes a suburb. But it may have derived partly, as well, from an unwillingness to be vilified by association. Karl Jaspers, in his book on The Question of German Guilt, describes a third kind of reaction:

> In the summer of 1945, when in all towns and villages the posters hung with the pictures and stories from Belsen and the crucial statement, "You are the guilty!" consciences grew uneasy . . . and something rebelled: who indicts me there? . . . It is only human that the accused, whether justly or unjustly charged, tries to defend himself.

The defense, in postwar Germany, took the form of accusing the accusers. "There is generally nothing to which we are so sensitive," Jaspers concluded, "as to any hint that we are considered guilty. . . . The greater this sensitivity to blame, the greater, as a rule, is the inconsiderate readiness to blame others." (19)

To take another example, this process of "moralistic poisoning" operated prior to the American Civil War in taking the disputants past the point of reconciliation. Progressively more violent rhetoric from the abolitionists, appealing to a higher law, characterized Southern slaveholders as devils incarnate. Refusing the imputation of guilt, Southerners depicted the ante-bellum south as a paradise for happy, healthy Negroes and launched an indignant counter-attack against Northerners as fanatic fomenters of bloody insurrection. "Paranoia," as C. Vann Woodward put it, "continued to induce counterparanoia, each antagonist infecting the other reciprocally, until the vicious spiral ended in war."(20)

Perhaps, it will be objected, such comparisons exaggerate the seriousness of the division between the two societies. Perhaps it is hyperbole to suggest an anology between the concentration camp and the urban ghetto. Perhaps it is irresponsible rhetoric of the very kind I am protesting against to invoke the spectre of another Civil War. I certainly hope so. Yet every indiciation in 1971, as in 1968, is that "the urban crisis will worsen, and . . . nothing much will be done about the crisis unless white America permits a radical change of public policy and undergoes a miraculous change of attitude toward its cities and their populations."(21)

Traditionally, Americans have disliked cities and sought to create alternatives. One hundred years ago, only the rich could afford the alternative of a suburban home. In the last 25 years, the American middle-class has staked its claim to a house and a plot of ground in suburbia. In the years ahead, we must make that alternative available to the working class. Only then will it be possible to clean out and rebuild our cities and bring the two Americas together.

If the way is to be found, the white middle-class suburban American who now dominates the nation in numbers as in political and economic strength must reject the debilitating burden of collective guilt and embrace instead a constructive sense of individual responsibility. He will have to be educated, as the Kerner Commission tried to educate him, in the gravity of the problem. He will have to be persuaded that it is in his own self-interest to cooperate in finding solutions--that if he does not take responsibility now, he will have to accept the consequences tomorrow. This won't be easy: miraculous changes in attitude never are. But perhaps it can be accomplished if the rest of us lower our voices and stop calling him names.

Notes

(1)Report of the National Advisory Commission on Civil Disorders (New York, 1968), p. 1.

(2)Jack Patterson, "The Wall of Zoning," Commonweal (28 May 1971), p. 284.

(3)"Liberalism in the Suburbs," Newsweek (6 July 1970), p. 57.

(4)David K. Shipler, "The Moral Dilemma of Zoning," Nation (3 August 1970), p. 80.

(5)"Will the Suburbs Beckon?" Ebony (July 1971), p. 112.

(6)Alice Miel and Edwin Kiester, Jr., "The Shortchanged Children," New York Times Magazine (16 April 1967), p. 99.

(7)"Dividing the Cake," Time (13 September 1971), p. 47.

(8)In this survey, I read all of the articles on the suburbs listed in the Reader's Guide to Periodical Literature from March 1966 to September 1971. Only one article, in Mademoiselle, attempted (unsuccessfully) to take a humorous approach.

(9)"'One Person, One Vote'--Suburbs the Real Gainers," U.S. News and World Report (14 February 1966), pp. 66-67; "The Rise of Suburban Power," Christian Century (11 October 1967), pp. 1275-1276; "Suburbia Regnant," Time (6 July 1970, p. 6; "Suburbia: The New American Plurality," Time (15 March 1971), pp. 14-20; J. Robert Moskin, "The Suburbs: Made to Order for Crime," Look (31 May 1966), pp. 26-27; "The Golden Days Are Gone in Suburbia," Business Week (5 September 1970), pp. 34-35, 38-40.

(10)Jack Patterson, "The Wall of Zoning," Commonweal (28 May 1971), pp. 283-285; David K. Shipler, "The Moral Dilemma of Zoning," Nation (3 August 1970), pp. 80-83; "Battle to Open the Suburbs: New Attack on Zoning Laws," U.S. News and World Report (22 June 1970), pp. 39-40; "'Snob Zoning,'" New Republic (20 and 27 December 1969), p. 7; Linda and Paul Davidoff and Neil N. Gold, "The Suburbs Have to Open Their Gates," New York Times Magazine (7 November 1971), pp. 40-44.

(11)Webster Schott, "A Diamond Mined in the Suburbs," Life (1 July 1966), p. 20.

(12)Henry Maier, "Suburbia and the City: Flight, Fight, or Apathy," Vital Speeches (1 January 1970), pp. 186-187.

(13)William Hedgepeth, "Apostle to the Affluent," Look (16 May 1967), p. 41.

(14)Jimmy Breslin, "I Hate the Suburbs," Saturday Evening Post (24 September 1966), p. 10.

(15)"Second Chance for Suburbia," Christian Century (16 October 1968), p. 1296.

(16)Karl Jaspers, The Question of German Guilt (New York, 1947), p. 40.

(17)Michael Halberstam, "Are You Guilty of Murdering Martin Luther King?" New York Times Magazine (9 June 1968), pp. 27-28.

(18)"Suburbia: The New American Plurality," Time (15 March 1971), p. 14.

(19)Jaspers, pp. 47, 107.

(20)C. Vann Woodward, "John Brown's Raid and the Abandonment of Non-violence," in Richard O. Curry, ed., The Abolitionists (New York, 1965), pp. 97-106.

(21)Herbert J. Gans, "The White Exodus to Suburbia Steps Up," New York Times Magazine (7 January 1968), p. 24.

ENVIRONMENTAL QUALITY: SPECIFICATION AND EVALUATION

8: INDICATORS OF ENVIRONMENTAL QUALITY

ENVIRONMENTAL INDICATORS: AN OVERVIEW

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The value of being able to measure progress toward important societal goals is readily apparent. Yet it is only within the last few years that substantial resources have been directed toward this end. In fact, the shift of intellectual and governmental resources in this direction has been so rapid that it has been described as a "movement"--the social indicators movement.[1]

The rapid growth of interest in so-called "social indicators" seems to have been a direct outgrowth of the increasing concern for social problems (particularly poverty and race) and environmental issues, starting in the early 1960's. As these matters came to the forefront, attention turned to the role that economic indicators had been playing. They had been important tools for monitoring business cycle changes and rate of growth in the output of goods and services for some period of time. They were being used extensively in both governmental and private decision-making. It was equally apparant, however, that the economic indicators provided signals of progress or retrogression in only a limited realm; they said very little about other aspects of the quality of life. Non-economic indicators were seen as needed to monitor change in these other aspects of life. These were generally labeled "social indicators", usually employing the term "social" in a very general sense, extending far beyond the more narrowly defined social issues of race and poverty, education, health and welfare. Thus, it is interesting to note that the first major formal product of this movement, a report produced by the Department of Health, Education and Welfare in 1968, entitled "Toward A Social Report," covered the following topics:

Health and Illness
Social Mobility
Our Physical Environment
Income and Poverty
Public Order and Safety
Learning, Science and Art
Participation and Alienation

While semantics here are not of the greatest moment, there is some gain in clarity in using the generic term "indicators", with descriptive adjectives attached to characterize them, so that one can refer to social, economic, political or environmental indicators depending on the subjects covered. There is a more serious problem. The term "indicators" or "social indicators" is being used to cover a great variety of different kinds of data, and in some cases just about any non-economic datum is referred to as a "social indicator." Here the matter is substantive and is of some importance. Certain distinctions among the different kinds of data series are essential to enhance understanding. There are of course, many possible ways of characterizing data series, depending upon one's objectives. I will refer to one useful set of distinctions, mainly to focus on the special characteristics of indicators. The important point to note is that only certain kinds of data meet the key indicators' criterion--the ability to measure "output" or end-results. Other kinds of data have different purposes, and should be recognized for what they are. Important among these are the following:

A. Non-Indicator Data Series:

1. Descriptive data. Such data help to describe or characterize a given situation. In this category is the datum that there were some 7 million persons in Los Angeles County in April 1970, as compared to 6 million in 1960. If the County had a recognized policy of trying to keep population stable, then the percentage increase could be employed as an "indicator" of the success or failure attained in achieving this objective. Without such an accepted goal, the population numbers series is a "descriptive" one. Most statistical series (including a large part of the Census data) are in this category.

2. Program "input" data. The number of students per teacher, and changes in this number over time, is a typical example of input data in the field of education, sometimes unrealistically used as a measure of output. One has to get to a measure of the education that the students have acquired (say, in terms of relative reading skills) before he can claim to have an output measure or an indicator. The number of air pollution monitoring stations in a given region this year as compared to 10 years ago would be the same kind of "input" measure, as would be the number of building inspections per year, or the number of garbage collections per week.

3. Program or functional performance standards. Such standards are often set by professional associations, or they may be in the category of conventional (or traditional) standards within a given culture. In this grouping are data on the number of acres of recreational space per 1,000 population compared to a certain standard of acres per 1,000 population set by the recreation association. In the same category is the percentage of housing units in a given Census tract having 1.01 or more persons per room (compared to the past or other areas). If a given community were to accept the no-more-than-one-person-per-room standard as an official planning goal, then these figures could be taken as an indicator (rather than merely as a Census statistical series).

B. Indicators:
The main point has already been made. In the indicators category, we are specifically concerned with "output" measures, answering the basic question: "How are we making out in a given area of life?" Here it is useful to make further distinctions between three kinds of indicator measures or data series:

1. Societal situation. These are measures of the condition of people in our society in general or within a given community. Thus, accepting longevity as a "good", average longevity this year compared to certain years in the past (or compared to other countries) may be taken as an indicator. The same would be true of any other measure of "a good" or major societal goal, whether increasing income, or full employment, or political participation, or upward mobility, or relative air and water purity, or whatever.

2. Program (or functional, or service) output. The distinction between the first and second category is generally not clear cut. Where an output is closely associated with a governmental service (such as education) or a set of public and private services (such as health or transportation), the indicators may be employed to measure program performance to some extent. Thus, an indicator such as sickness-free days may be taken as a measure of performance of our health services taken as a whole. Actually, where the distinction is easily made, and the program is narrowly operational (say, in the case of garbage collected or water of a certain standard delivered), probably we are no longer dealing with an indicator having output characteristics, but the statistic is more appropriately thought of as an input measure or a measure of operational quality (in the sense that delivered pure water is an input in health, where "sickness-free days" is an appropriate societal output measure of health).

3. Measure of system effectiveness. This is an exceedingly complex category, but an important one. There are situations where it is difficult to conceive a societal output measure, for example, the receipt of "justice." Yet, clearly, the question as to whether a given society is becoming less or more just may be of the greatest interest. In such a case, a reasonable approach may be to turn to the measurement of system effectiveness. Thus, the relative delays faced within the judicial system by individuals within different income categories or different age groups may be taken as one measure of system effectiveness against the standard of equal treatment for all. Where concern is "due process," or fairness (e.g., in accessibility to public services), or equity, we may well have to fall back on measures of system effectiveness to get at outputs or end-results.

On the Nature and Uses of Indicators
The purpose of all this exercise in categorization is not to achieve some abstract kind of purity. Indicators, however, have a special purpose and it is for this reason that concern for the nature of the data series being used makes sense. They are to serve the ends of policy making, both to assist in more appropriate governmental and private decisions (that is, appropriate to the more ultimate ends sought) and to permit a broader base of popular participation. The extent to which Gross National Product and the Commerce Department's eight so-called "leading business indicators"[2] are employed by both government and private enterprise in coping with the business cycle provides a notion of the potential value of well-designed indicators. Overwhelming masses of data of different kinds directed at decision-makers or the general public, we know from experience, tend to be pushed aside and little used. The data have to be sharply focused, dramatic in impact and readily understood if they are to be widely and appropriately used. This sets very high standards for indicators, whether social, political, environmental, or economic. Unless a small number of indicators can provide a highly meaningful and accurate picture of what is going on, they are not achieving their main objective. This is not to propose a policy of perfection. Rather it is to stress the ultimate value of indicators as policy tools and the need to recognize the fact that it is better to continue to utilize masses of different kinds to data (fully appreciating their limitations in providing a base for policy) than to turn to indicators until research has proved them out to be accurate, meaningful and indicating what they are supposed to indicate.

Environmental Indicators Within a Larger Context

The early and almost sole attention given to economic indicators in the 1930's, 1940's and 1950's reflected the very high priority attached to overall economic growth and business cycle stability (and reflected as well the progress made in the study of economics). Economic growth and business-cycle stability were sought as end products, almost to the exclusion of other considerations. By contrast, the factors that gave rise to the so-called social indicators movement reflected a wide set of concerns, including equity (fair-shares) considerations, inadequacies in social, political and environmental conditions, the costs (as well as the benefits) of economic growth, and related matters.

These concerns set certain requirements or standards for indicators, if we are to take them at all seriously. Clearly, it may not be possible to meet optimal standards for some period of time, until extensive research on indicators has been carried out. At this stage, it is useful, at least, to consider the nature of what we should be aiming at.

1. Consideration of various facets of life in interrelationship. This grows out of our concern for the links between various of our goals (and means), and the "trade-offs" involved. Thus, most strikingly, there is strong interest in the relationship between economic growth and the human or social costs associated with such growth, particularly in environmental deterioration and social disorganization. Links between economic power and political power is another area of broad interest. Even aside from linkages that it may be possible to establish, there is interest in knowing in which aspects of our lives things are getting bettter and in which worst. This has grown out of a widely held fear that we may be getting more affluent (particularly in terms of private goods and services) only to lose out in other highly regarded aspects of human life.

All this suggests that indicators can achieve their greatest usefulness when those concerned with one aspect of life--such as environmental quality--can be directly linked to other aspects --political, economic and social.

This is not to suggest that indicators touching on one facet of life cannot be of great value. Surely, indicators of, say, air quality can tell a useful story. Such indicators can monitor progress or retrogression in a given field in which there is substantial public interest. Viewed in terms of what is desirable, however, we should be able to say whether, for instance, improvement in air quality is at the expense of water quality or the solid waste that has to be coped with (since these three forms of waste removal are inter-locked). Beyond this, we would want to know whether or not improvements in the built environment and in circulation are at the expense of the natural environment. The most striking example here is, of course, the possibility of improving a given transportation situation at the expense of air quality. Beyond this, there are clearly other interrelationships--for example, between what is happening in terms of a regions's economic expansion and what is happening with regard to environmental quality--that suggest the value of indicators developed and presented in an interlinked fashion.

2. Breakdowns for major societal groups. This grows out of the increasing concern for equity (fair-shares) considerations and a recognition that not everyone in our society is gaining equally or losing equally.

The indicators most widely used in the past, the economic indicators, have largely been concerned with broad national averages or across-the-board averages for regional (labor market) areas. In the last few years, there has been an increasing demand for data on the economic situation for various groups in our society, particularly minotity groups, and various agencies, notably the Department of Labor and the Office of Economic Opportunity, have begun to provide data series which reveal differences in the economic situation for various groups. Many of the most useful data in this category are still provided on an ad hoc basis, however.

It is hard to conceive of meaningful public policy being evolved without firm data on the relative situation for the various societal groups and the relative improvement or retrogression for such groups in all the major realms of life, social, political and environmental as well as economic. For most situations, breakdowns are required for all of the most common statistical categories: ethnic-racial, age, sex, occupational and educational groupings. In addition, when the focal point is a sizeable city or urban region, valuable information is provided when there are breakdowns for the various territorial communities, paricularly where various ethnic-racial and occupational groups predominate (such as minority or blue-collar areas). For example, it is hard to say anything that is very meaningful through environmental indicators covering a total metropolitan region. It is necessary to pinpoint relative situations and relative changes in the environmental conditions of minority groups as compared to the middle class white groups, (for Watts as compared to Beverly Hills or Westwood in Los Angeles, for example.

3. Evolving indicators through a feedback operation. The major use of indicators is in public policy-making. Once we depart from

narrow business-cycle considerations, and enter the realm of "quality of life" measures, we also enter a realm where value judgments and political implications predominate. It is difficult, to say the least, to lay claim to one set of indicators as "objectively" representing changes in human welfare and quality of life. Different groups have varying views of what is important in their lives and these views, in fact, change over time. Moreover, indicators which lay claim to public attention (whether published officially or not) carry with them important political implications. Whether intended or not, they bring attention to certain situations and neglect others and the form they take will also normally have policy implications. This suggests two major requirements for indicators dealing with quality-of-life considerations: (1) "subjective" as well as "objective" views concerning various aspects of life should be recorded, and (2) direct techniques for community feedback should be developed.

Perceptions of human welfare and quality of life by different groups is (or should be) an important consideration in policy making. It is not enough to know what officially-provided data series indicate (or what research series may show) about changes in welfare. We also have to know what people think is happening to them and what their situation is. It is not enough to have a series which shows that housing in a given area is better according to "objective" standards. We need to know if the residents in the area think their housing is or is not better, since this is critically important in how people feel about their situation and about public policy. Such perceptions and views can be recorded through survey research techniques. While these methods have serious limitations (many of which are analyzed in the literature), they do, at a minimum, help to formulate useful questions about changes in quality of life and help in warning against using the "objective" data with more assurance than they deserve.

Once we accept the notion that views about what is important in human welfare and quality of life are certain to vary among different groups, it becomes incumbent upon researchers in the field of indicators to interrelate with people in the community, so that these varying views can be effectively recorded. If some groups are more concerned with the status associated with their housing than with the condition of the physical house, then this should come to the forefront in one way or another and not the initial assumption (or instinctive view) of the researcher. Some of this can be learned through the survey research methods mentioned above, but direct feedback--by exposing earlier versions of indicator reports to community groups--would probably reveal considerations not recorded through interviews alone.

Very little has been done in the past in obtaining community feedback to either official or university-research reports. It has generally been assumed that information is a one-way stream, from the government or university to those members of the community who happened to be interested in the information provided. However, if indicators are genuinely to reflect the monitoring of those aspects of life most highly regarded by various groups in the community, then it is an essential part of indicators research to establish a flow of information from the community to the researchers (with a serious effort made to reach members of the community not generally reached), and techniques developed for a continuing two-way flow of information. Moreover, researchers in the indicators field should be sensitive to the social and political implications of what they are doing, concerned that what is produced is genuinely helpful to various groups in the community.

The Subjects to be Covered by Environmental Indicators

One additional "overview" consideration deserves attention: what environmental indicators should cover. Here, again, semantic problems tend to emerge. "Environment" is often used in very broad senses, as when we speak of "a democratic environment" or "a cultural environment." We should be able to assume that such considerations, if deemed important, would be covered by indicators treating the social, political or economic realms. The physical environment is normally not so treated and clearly deserves independent status in indicators work.

Given the many special uses to which indicators may be put, there are any number of ways in which the physical environment can be conceived and covered. For general purposes, that is, when a wide variety of uses related to public policy making and private decision-making is anticipated, four major categories (all inter-linked) can be usefully identified:

1. The natural environment, including the condition of the airshed, watershed, open space recreation "shed", quiet-and-noise zones, sunlight exposure, and the spatial environment (including underground space, land, and air-space).

2. The transportation-utilities environment, the various networks that tie the urban region together, including transportation (accessibility), communications, electric power, water, sewerage, and the like.

3. The community-or-neighborhood environment, largely defined in terms of common pub-

lic services and accessibility or location characteristics, but covering all important interactions between people and physical environment.

4. The microenvironments, mainly the household shelters and the work places, generally within the setting of the community-or-neighborhood environment.

"The framework that is thus provided can be described as one of several environmental 'envelopes' (although the term should not be taken too literally) through which the quality of the urban environment can be characterized: the large natural resources and space-use envelope, the community-neighborhood envelope, and the home and work microenvelope, all tied together in various ways and literally tied together through the transportation-utilities set of networks."[3]

Since environmental indicators tend, in general, to characterize external conditions--for example, the extent to which the capacity of the airbasin is being strained by the pollutants injected, or the noise level in a given area--it is particularly important that there be monitoring of human perceptions of these conditions and the relative sense of satisfaction or dissatisfaction associated with the conditions. The main question is not how the environment is making out, but how human beings are making out in relationship to the environment.

The problems involved in developing indicators which can meet the standards established here will be the subject of separate papers, both at the present conference, and in later reporting on the indicators research currently under way within UCLA's School of Architecture and Urban Planning.

Footnotes

1 The development and potential role of social indicators are discussed in Raymond A. Bauer, Social Indicators (Cambridge: MIT Press, 1968); Center for Urban Studies, Wayne State University, Social Reporting in Michigan: Problems and Issues, Technical Report A-37, Office of Planning Coordination, State of Michigan, February 1970; Otis Dudley Duncan, Toward Social Reporting: Next Steps, (New York: Russell Sage Foundation, 1969): Bertram M. Gross, "Social Goals and Indicators for American Society," Annals of the American Academy of Political and Social Science, Vol. 371, May 1967, (See also Vol., 373, September 1967); Daniel Bell, "The Idea of a Social Report," Public Interest, Spring 1969, pp. 72-84; Eleanor B. Sheldon and Wilbert E. Moore, Indicators of Social Change, (New York: Russell Sage Foundation, 1968).

2 The "leading business indicators" cover the following: common stock prices, contracts and orders for plant and equipment, new orders in the durable goods industries, average weekly initial claims under state unemployment insurance, new housing permits, industrial materials prices, and average work week in manufacturing.

3 Harvey S. Perloff, "A Framework for Dealing with the Urban Environment," in The Quality of the Urban Environment, edited by H.S. Perloff (Washington, D.C.: Resources for the Future, Inc., 1969), p. 19.

INDICATORS FOR HOUSING POLICY

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The Problem

If the housing problem can be solved in the City of New York -- if a "suitable living environment" can be provided for all seven million plus residents of the nation's largest, most densely packed city, with its high levels of pollution, crime, deterioration, congestion, segation, unemployment, welfare burden, and general dissatisfaction -- it can be solved anywhere in the country. The basic approach to solving it in New York, for the last two decades, has been to concentrate on new construction and rehabilitation, to increase the total supply of standard housing available in the city. Given probably the lowest rental housing vacancy rate of any major city in the country, the approach seems a reasonable one. The New York City Plan Commission's recently released mammoth new Master Plan says: "New York City's chief housing problem has been a shortage of units." The problem seems clear, even if its solution is not.

By the same token, the measurement of the problem also seems clear: if the number of substandard occupied units is known, and the vacancy rate is known, a good general picture of the situation can be derived; perhaps supplementary data on income and rent levels, location, and some other non-esoteric information is needed in addition to know just where and for whom the problem exists and whether progress is being made towards its solution or not. The indicators problem in the field of housing does not seem to be particularly difficult, either in terms of theory or of data.

Now suddenly appears an article on the front page of the New York Times Real Estate Section (1) about this very problem with the Headline: "A 'Housing Shortage' It Isn't." In its first paragraph, the clear and succinct analysis provided in the new Master Plan and quoted above is dismissed with the comment, "Nothing could be further from the truth." And those most cherished of housing indicators, vacancy rates, number of standard units, and rents, are swept away with one sentence:

> It is irrelevant how many vacant standard housing units exist with all facilities and at reasonable rents...

The author of these statements was no iconoclastic academic out to make a name for himself, but rather Frank Kristof, a professional cononist who should know whereof he speaks: he served in the past not only with the Bureau of the Census' Housing Division, but also with the New York City Housing and Development Administration, and is currently Chief Housing Economist with New York State's Urban Development Corporation.

Kristoff's specific concern in the New York Times article is with the phenomenon of abandonments, which he relates to neighborhood developments not reflected by the standard housing statistics. But even before abandonments came to be the housing problem of the year, the inadequacy of housing statistics as a clue to the nature and extent of housing problems could be deduced by those that wanted to. Pruitt-Igoe showed up splendidly in the statistics; Watts and Hough, as far as quality of the physical housing units was concerned, looked like slightly lower-middle class suburbs; the housing project in Newark whose tenants were driven to revolt in the nation's leading riot showed up as a concentration of good housing in a sea of bad. The intuitive feeling that the quality of the residential environment in most of our big cities is getting worse has not been reflected in the housing statistics. (2)

This is not for lack of figures.

Existing Housing Indicators

On the physical quality of shelter, for instance, we have now had three complete nationwide unit-by-unit enumerations of the physical quality of housing, its facilities, rental levels, etc. The 1960 census contained an account of the number of housing units, room per unit, number of persons per room, rent or house value, rent-income ratio, adequacy of plumbing facilities, and physical conditions (standard, deteriorating, dilapidated), and occupancy, seasonal or non-seasonal status, by selected demographic characteristics, for all housing units in the United States.

But the accuracy of these figures has been extensively criticized. (3) The number of dilapidated units was, for instance, in the Census Bureau's own later evaluation, understated by as much as one third, largely because of variations in the rating of different enumerators. In preparatory work for the 1970 census, means were sought to avoid these errors and yet find a meaningful objective measurement of housing quality. After pilot studies of the correlation between dilapidation and a wide variety of simple and unequivocal conditions of the structure, including consideration of correlation with type of kitchen facilities, rent, income, density, and other factors, it was concluded that no sound correlation could be found. (4) Since the 1970 census will not be on a door-to-door basis, but will rely in large part on questionnaires, information on quality of structure *per se* has been dropped and will not be otherwise available in the census. It will include information only as to number of year-round dwelling units, availability of plumbing facilities and whether shared, rental or value, owner or tenant occupied, with Negro head of household, with more than one person per room, and with or without both spouses present.

Sophisticated commentators are more and more conceding the inadequacy of the available measures to reveal those factors crucial for the development of policy in housing. Frank S. Kristof, (5) for instance, in the Douglas Commission's assessment of national housing needs, said in 1968:

> Given the problem of changing standards of acceptable housing over time, a question arises about validity of the criteria of housing needs adopted in this paper for purposes of measuring the need. Such a question applied particularly to the concept of substandard housing as defined on the basis of census criteria. Many persons have been critical of this measure, particularly since it fails to recognize, except obliquely, many deficiencies defined in housing codes such as interior rooms, inadequate size of rooms, certain fire hazards, light and air requirements.
>
> In addition, this measure does not encompass environmental deficiencies that are today accepted as contributing to lack of livability of a given neighborhood. Examples of such deficiencies are garbage-littered streets arising from poor sanitation services, cracked and broken sidewalks, unpaved or broken streets, missing or ineffective street lights, inadequate sewage and drainage facilities, and the mixture of noxious, noisy and heavy traffic generating commercial and industrial usage in residential areas. Others would add social disabilities such as the danger of assault, mugging and robbery in "high hazard" neighborhoods with high concentrations of unemployment, juvenial delinquency, and narcotics traffic and addiction.

Nevertheless, the measure of "substandard units" continues to be used to evaluate progress in housing in the absence of any operational substitutes.

Even where the available figures do measure something clearly critical for national policy, the conclusions to be drawn from them vary. For example, three recent special reports of the Bureau of the Census give quite different impressions as to changes in the quality of housing of Negro families between 1960 and 1968. Each has a section dealing with conditions in low income areas. The first states "the proportion of non-white families in large cities living in poverty areas has declined sharply since 1960. The drop has been greatest in cities within the largest metropolitan areas." (6) The second states "Negroes are also proportionately less likely to live in poverty areas of large cities than before. In 1960, 77 percent of all non-white families living in large cities resided in the poverty areas of these cities. In 1966, the percent was 62; in 1968 this proportion was down to 56 percent." (7) The last and most recent report, however, states, "white families left central city poverty areas at a faster rate than non-whites between 1960 and 1968, resulting in an increase in the percentage of poverty area families who were non-white. There was a 35 percent decline in the number of white families residing in poverty areas of large cities as compared with a drop of only 10 percent in the number of non-white families." (8) Has the housing of non-whites gotten "better," or "worse"? There is no dispute about the statistics; what conclusions can be drawn from them, and whether the net result is improve- or further deterioration, is susceptible to differing interpretations.

The same type of comment is applicable to the detailed and carefully worked out segregation indices of the Taeubers. (9) An increase in residential segregation might be seen as an indicator of an increasing problem on the American housing scene. The Teaubers' index, however, compares segregation with a city standard, and gives no indication of whether by overall national standards Negroes are becoming more or less concentrated in cities. It does not include a metropolitan index, although it contains some evidence that it might not differ much from that established for each city. It does not try to trace separately the impact of racial and economic factors, although the relative importance of each is clearly vital for national policy determination. It gives its results in percentage terms only, although an indication of whether the absolute number of minority group members living in segregated conditions may be more relevant than their percentage. Finally, and perhaps most important, it gives us no tool with which to judge if any of the segregation that was found was voluntary or not. At some point we have to decide whether it is a goal of public policy to obtain an equal proportion of all racial groups in every block or in every census tract in the city, and if not, what our racial goals are. Till then, even such a careful indicator as the Taeubers' is not very helpful.

The Department of Housing and Urban Development accumulates a massive amount of information on new housing construction and the construction and mortgage financing industries monthly. (10) The volume and cost of new construction is given, as well as type of financing, foreclosure rates, cost of materials, and so forth. The level of disaggregation is not very great, however; it is for instance impossible to tell to what extent the increase in the average price of new homes is accounted for by increased size of lot, increased size of building, or increased cost of construction. Vacancy rates are available quarterly; they are however broken down only between rental and owner-occupied, not by location or price. Further, they vary sharply from vacancy surveys conducted by the U.S. Post Office using its letter carriers. Market analyses of the demand for new housing are conducted periodically in select cities by the Federal Housing Administration; they leave much to be desired technically, and evaluate only effective economic demand.

HUD statistics are not assembled and aggregated or even evaluated as a whole to give a unified picture of what is happening to the nation's housing situation, nor are they apparently intended to be. They serve primarily the needs of the construction and lending industries and the Federal agencies, primarily the FHA, that deal with them. When a local public housing authority has to prove to the Housing Assistance Administration the extent of the need for low-income housing, or the level of rents available in the community, it must still start from scratch to make its own survey.

All of these weaknesses in housing statistics might perhaps be of only academic concern if they did not have a direct relationship to national housing policy. Unfortunately, they have a reflection and a rationalization, if not a cause, of a policy which is to production-oriented as to subordinate virtually every other concern of housing policy to the day-to-day desire to get units built. Whether the quality of the indicators used is a reflection or a cause of the policy is not particularly important. Just as a factory manager, whose performance is judged and rewarded on the basis of how many cars he produces, cannot be expected to care particularly about the safety dangers which the cars present, or who buys them, or whether the price is fair, or how much pollution they cause, or to what alternative use the steel of which they are made could be put, or how much they cost to run, so a national housing system which is judged politically by how many houses it produces a year cannot be expected to care particularly about environmental quality, what part of the market is served, at what cost, for how long, or with what trade-offs in terms of location, crowding, transportation, segregation, or other non-production factors. If housing policy is to become more realistic, housing indicators must be improved.

The social indicators movement ought to offer a fertile source for new approaches to the measurement of housing needs and housing progress.

Yet, surprisingly enough, Toward a Social Report (11) treats existing measures of housing condition as adequate without questioning their significance or commenting on the factors ommited. Bauer's Social Indicators (12) takes for granted physically "standard" housing as a basic need without any comment on the shortcomings of that concept as a true indicator of the extent to which the residential conditions in which the nation's population lives fall short of its goals.

The Douglas Commission and the Kaiser Commission have finally made a vigorous effort to pull together all of the available housing statistics to get some rounded picture of total national housing needs. Their efforts probably represent the most thorough and intelligent use that has been made of the statistics presently available from the Census and from HUD, and the Douglas and Kaiser estimates of needs are remarkably similar. Yet in each case, despite their appreciation of the shortcomings of the method, the resulting estimate is based solely on the physical condition of individual housing units and their cost, omitting environmental factors and social factors entirely. The current National Housing Goals reports do not even attempt any broader view.

The Urban Institute's experimental collection of indicators, illuminating as it is, uses the cost of standard housing for an average family as its measure of housing conditions. (13) Only when we come to the frontiers of the indicators movement as it presently exists, for instance in Harvey Perloff's brief discussion in the first article in The Quality of the Urban Environment, is there recognition of the importance of something he calls the "community-neighborhood environment," although the standard characteristics of the housing units are also considered and probably overstressed. (14) It is very hard to get away from.

Threshhold Problems with Better Indicators

The search for good indicators can be fun. Finding reliable figures can itself be a real challenge; analyzing their relationship to important trends raises constant fascinating problems of cause and effect, the dialectic change from quantity to quality, and so forth; and success expands our knowledge and understanding of the world about us, and is thus worthwhile of itself. But if our concern is not with indicators for their own sake, but with indicators as a guide to public policy, then "success" in finding good indicators has to be defined differently. To put it in a different way, there are certain "pure" criteria which may be established by which to judge indicators; beyond there, there are "policy" criteria which indicators must also meet if they are to be used in policy formation.

The "pure" criteria for indicators have been ably set forth by Mancur Olsen and others. They are simple and logical:

1. Indicators should be mutually exclusive: there should be no duplicate counting.

2. They should be complete: putting all indicators together, all relevant factors should be covered.

3. They should be aggregatable: some common unit of measurement or other device should be available to permit a conclusion as to the net direction of development.

These "pure" criteria apply in general to any set of indicators for any purpose. Policy-oriented indicators should, in addition, meet the following "policy" criteria:

4. They should be based on information that is readily, quickly and cheaply available, since the lead time in housing development is longer than in many other fields.

5. They should be separable into geographically localized components, since many of the remedial actions must be taken locally.

6. They should be sensitive to the specific effects of public actions, while measuring outputs, they must illuminate the related changes in input.

7. They should reveal the intensity, as well as the extensiveness, of short falls from social goals.

8. They should reveal the differential effects of given trends on different groups within the population.

9. They should be simple and readily understandable in the context of political controversy.

10. They should at least indicate when major spill-overs outside the field of housing are likely to be involved (or to cause) changes in housing, both on the cost and the benefit side.

Clearly fulfilling these criteria presents some threshold problems. Take the question of the groups affected by certain housing policy, for instance. At least 8 clearly distinguishable groups are affected differently by virtually any housing policy; they are listed in the following section. Giving freedom of choice of neighborhood to group A may restrict group B's freedom; subsidizing A's ownership of house X means it is not later available for rental to B, even after A strikes it rich; shifting from new construction to rehabilitation may put some out of work, and create new jobs for others. Unless we have some universally accepted method of making interpersonal comparisons of utility, we need to differentiate between groups in our indicators

A second threshold problem lies in the definition of inputs. For housing, the answer appears deceptively simple. Not too many generations ago, our ancestors could look at a pile of logs and know that they had before them all the essential ingredients to house their families, protect them from the elements, and provide them with heat and fuel. If pushed, the land on which the house was to be built might have been added as an "input"; and the manpower necessary to hew the logs and stack them might, to one philosophically inclined, have been called an "input" also. But there it stopped.

Our national housing policy often seems not to have progressed much beyond a concern with the building methods and meterials included in this definition of housing inputs. (15) Its weaknesses are obvious. Even the quality of the physical shelter afforded by the house cannot be predicted from these limited inputs. How good the fire department is may have more to do with how safe the structure is than what it is built of. Whether repairs are made regularly may be more important than how sound the structure is to begin with. Going beyond physical shelter, whether a house provides security and satisfaction today may have more to do with who the neighbors are than how thick the front door is. The location of the house, relative to other houses, to community services, to job opportunities, to environmental amenities, may be crucial in judging its adequacy.

Outputs present similar problems. Everybody knows that the output of a housing policy ought to be houses, and we have ample sophisticated means of measuring the quality of housing. The American Public Health Association's set of standards makes a good-sized volume. If a "suitable living environment" is part of the output of a housing policy, the APHA has a set of standards for that, too. But even the APHA, the organizational veteran of many years of the housing wars, is having afterthoughts about the meaning of its standards, and is rethinking the whole subject. The basic problem with such standards is that they are fundamentally input measures, not performance or output measures. Things like health, comfort, security are much more nearly the outputs of housing. This is a third threshold problem. Very little of the literature, and even less public policy, is devoted to a head-on attempt to deal with the ultimate outputs of housing.

Lack of understanding of both the housing market and how housing affects people is a fourth threshold problem.

Our knowledge of the field of cause and effect relationships, is simply not well enough developed to enable us to predict which present problem will be tommorow's forgotten foible and which its hidden crisis. Thirty years ago homwownership was seen as a snare and a delusion; fifteen years ago sururban one-family housing construction seemed to know no bounds; today apartment building has exceeded one-family construction for the first time in recent history. Segregated housing, public housing, open housing, fair housing, and now improved ghetto housing have appeared successively as the solution to the racial problem. Empirical evidence is hardly available to show what precise effect each will have, because, except for segregated housing, none of the other possibilities has really been tried as yet. Straight-line projections of existing trends are indeed possible, but unreliable, and the likelihood that from examination of the indicators new problems can be anticipated before they arise is slim. Progress in this direction must await further work on cause-effect relationships in housing, environmental design, and related fields.

A fifth threshold problem lies in the complexity of "progress" in housing. Where progress does not go in a straight line forward, indications of progress, even where the indicator itself is accurately measured, can be misleading. If the positive values of a particular ethnic enclave outweigh the disadvantages of the substandard housing it contains, an indicator of the extent of demolition of substandard units through slum clearance may be read as a sign of progress, even though the opposite is the case. If heightened dissatisfaction with housing by its occupants is needed to bring about corrective measures, an indicator of satisfaction will be ambiguous. In the long run, the more satisfaction, the better. In the short run, satisfaction may be the result of anomie, and counterproductive. Security of tenure seems to be contradicted by an increase in foreclosures; yet experience of new families with homeownership, which may result in higher foreclosures, may also be the path ultimately to more wide-spread ownership. Dislocation and temporary worsening of housing accommodations may have to be the price many families pay for better ultimate housing.

Rather than stop work on actually developing indicators till all of these threshold problems are resolved, the effort actually to find and use indicators may shed some light on the problems that could not be solved in the abstract. In that hope, a policy matrix is suggested below which may serve as a framework to advance at least one step ahead in developing indicators useful in the field of housing.

A Tentative Policy Matrix for Housing Indicators
The policy-oriented indicators matrix suggested here has three dimensions: inputs, groups affected, and outputs.

Inputs are divided into six broad parallel categories, which can be shown schematically as follows:

	The Individual Unit	The Residential Environment
Physical	building structure, plumbing, heating, etc.	streets, sewers, etc.
Service	maintenance, utilities, etc.	garbage pickup, police protection, etc.
Socio-economic	tenure relationships, occupancy payment, etc.	ethnic composition of community, political powers, etc.

The classification of any item into any of these categories may be arbitrary, and there is no magic about the categories themselves. They are simply one systematic way to search out and arrange the wide range of inputs which contribute to that set of outputs we call "housing."

Groups affected should include at least the following eight categories:

1. The current occupants of the housing being assisted (the intended beneficiaries of the policy in question).

2. The projected future occupants of the "good" housing (the intended beneficiaries of the policy).

3. The entire group of those not having "good" housing (those "in need" of housing.

4. The alternate users of housing, or the land on which it is built (those dislocated to make room for it, and/or those who would use it were it not for the policy).

5. The particular ethnic, religious, class, age, economic or other group with which

the current beneficiaries of the policy identify, or with whom their interests are most closely linked.

6. The residents of the housing market areas affected by the policy in question.

7. Those most directly affected by the costs of the policy in question, generally in the form of taxes.

8. The other economic interests (other than occupants) affected: construction trades, real estate speculators, public bureaucracy, etc.

Output definition is the knottiest problem of all, and can only be touched on here. The ultimate "outputs" of housing are such general things as health, comfort, economic well-being, security, status, esthetic enjoyment; in a sense, "happiness" might be considered the ultimate relevant output of all outputs. Some intermediate level might include things like shelter, warmth, accessibility, economy, protection against injury, appearance. A clustering of intermediate outputs will probably be used in the development of the present matrix. In any event, a good bit more work needs to be done in refining these concepts, and perhaps a hierarchical arrangement similar to Maslow's will ultimately prove useful. The essential point, in any event, is that the focus has to be the output of housing as a totality of consequences for individual human beings, not as piles of brick and mortar, landscaped and located in space.

Taking one problem set through the matrix shows some of its difficulties and its possibilities. "Security" is one of the characteristics of the residential environment with which there is much concern today. Personal physical security certainly should be improved, not worsened, by public policy. It is a key output of housing. No direct indicators of change in this output, as it is affected by housing, are now available. How would we go about looking for one?

First, of course, there is the problem of measuring the dimension of output directly. We can count how many persons are being burglarized, mugged, assaulted in their homes or their neighborhoods. But peoples' fears are as relevant as the reality of that which they fear: perhaps questionnaires would establish their perception of their own security? Suppose we had these direct output measures: for policy purposes, we would still need to know whether percentions are related, directly or otherwise, to the reality of number of muggings, or to other inputs. For instance, increasing the number of foot patrolmen or strengthening locks on doors, or closed circuit TV, or less sensationalistic reporting, or the election of a police chief as mayor, or better school-community or police-community relations, may all make people feel more secure; each of these inputs should be measured at the same time as the output is measured.

If the specific question is how housing policy inputs affect security, the six input categories suggested in the matrix would include strengthening the lock on the door, having common corridors visible from the outside, or TV cameras (connected or not!) in the elevator with the category of the individual physical unit. A full-time doorman or a private security guard would come within the individual unit-Service category. Friendship with neighbors, patterns of mutual assistance, concern by the landlord, may be important socio-economic inputs related to the particular residence.

On the Environmental input side, relevant physical characteristics would include street lighting, police call boxes, relationship of houses to each other; service inputs include the level of police protection, education, social services; and neighborhood environmental characteristics include homogeneity of population, the sense of "community," economic characteristics, level of employment, and so forth. Indicators of what is happening in each of these input areas is essential before policy conclusions can be drawn from indicators of output.

Different groups are affected differently by changes in these inputs, and one man's security may be another man's exposure. Many southern towns traditionally had de facto curfews against blacks in white neighborhoods. Such a policy in Cicero, Illinois, would undoubtedly make its white residents feel more secure -- whether it would do so in reality is of course an entirely different matter -- but would hardly improve the security of its black residents. Expanding police powers of search and seizure, wire-tapping, no-knock laws, may all improve the security of some and detract from that of others. Keeping families with police records out of public housing may make public housing residents more secure, slum dwellers less. Differentiation by group is essential for indicators to be meaningful.

Finally, changes in other outputs than security may accompany particular policies designed to affect only that output. Rents or taxes may go up to pay for a particular policy, and different groups will have to pay that price in terms of a reduction in the output of economic well-being they receive. More secure buildings may be uglier buildings; safer streets may be emptier streets, or less diverse streets; greater protection may be less justice. The whole gamit of outputs must be examined to see the full implications of a single policy.

The three-dimensional matrix thus theoretically permits analysis of any change in input as it affects any group as to any output. None of the ingredients in the matrix are really new, and the problems in converting it from a theoretic structure to a statistical reality are immense. But by stressing the distinction between input and output, the linkages between and among each, and reporting on both together, a set of indicators directly useful to public policy is more likely to emerge. The listing of changes as they affect separate groups differently should also have clear policy implications. Good work along these lines has already been done in cost-benefit studies and some systems analysis work, but it has not yet been integrated into the broader indicators movement.

In Towards a Social Report, three reasons are suggested for seeking social indicators: satisfying curiosity, making social problems more visible, and better evaluating the results of public programs. (16) Most figures thus far assembled achieve mainly the first goal. Much current work is now being done towards the second goal. The third goal is perhaps the hardest, but it is not too early to pay it attention. The goal being pursued does affect priorities among the work needing to be done -- the problem of aggregation, or comparability of units of measurement among different outputs, for instance, is less important for public policy than it is for intellectual curiosity. But the problems involved in working directly towards the third goal are great.

The demand for immediate policy relevance is a heavy burden to place on the shoulders of the social indicators movement, hardly yet able to walk on its own. It may well be counter-productive to discuss the possible remote uses of indicators at a time when their development is in such a rudimentary stage. On the other hand, in housing, as in so many other fields of public policy, one of the pitfalls has always been a failure to state goals clearly and succinctly and to think out their consequences within the full limits of available knowledge. Social indicators are supposed to be a help in avoiding such pitfalls. It would be ironic if the indicators movement itself failed to define its own goals, failed to find indicators of the quality of its own output.

The extent to which it can be used in measuring the impact of given public policy inputs on given groups in terms of all outputs should certainly be high on the list of those indicators by which the indicators movement itself can be evaluated.

Notes

1. THE NEW YORK TIMES, Real Estate Section, November 21, 1971, pg. 1.

2. For a further discussion of the inadequacy of present indicators, see the present writer's HOUSING POLICY AND SOCIAL INDICATORS, Working Paper No. 130, Center for Planning and Development Research, Berkeley, to be published in the Winter 1972 issue of URBAN AFFAIRS QUARTERLY. Some of the present material is taken from that article.

3. Bureau of the Census, U.S. Department of Commerce, MEASURING THE QUALITY OF HOUSING: AN APPRAOSAL OF CENSUS STATISTICS AND METHODS. Working Paper No. 25, U.S. Government Printing Office, Washington, D.C., 1967.

4. Young, Arthur F. and Joseph M. Selove, HOUSING QUALITY IN THE 1970 CENSUS, paper presented at the 1968 Conference of the American Institute of Planners, Pittsburgh, Penn., October 14, 1968.

5. Kristof , Frank S., URBAN HOUSING NEEDS THROUGH THE 1980's: AN ANALYSIS AND PROJECTION, National Commission on Urban Problems, Research Report No. 10, Washington, D.C., 1968, p. 88.

6. Bureau of the Census, U.S. Department of Commerce, SOCIAL AND ECONOMIC CONDITIONS OF NEGROES IN THE UNITED STATES, U.S. Government Printing Office, Washington, D.C., October, 1967, p. 93.

7. Bureau of the Census, U.S. Department of Commerce, RECENT TRENDS IN SOCIAL AND ECONOMIC CONDITIONS OF NEGROES IN THE UNITED STATES, U.S. Government Printing Office, Washington, D.C., July, 1968, p. vi.

8. Bureau of the Census, U.S. Department of Commerce, TRENDS IN SOCIAL AND ECONOMIC CONDITIONS IN METROPOLITAN AREAS, U.S. Government Printing Office, Washington, D.C., February, 1969, p. 64.

9. Taeuber, Karl and Alma, NEGROES IN CITIES, Aldine Publishing Company, Chicago, 1965.

10. U.S. Department of Housing and Urban Affairs, HOUSING STATISTICS, monthly.

11. U.S. Department of Health, Education, and Welfare, TOWARD A SOCIAL REPORT, U.S, Government Printing Office, Washington, D. C., 1969.

12. Bauer, Raymond, Ed., SOCIAL INDICATORS, Cambridge: MIT Press, 1966.

13. Jones, Martin V. and Michael Flax, THE

QUALITY OF LIFE IN WASHINGTON, D.C., Washington, D.C.: The Urban Institute, Working Paper 136-1, December 1969.

14. For instance: "The importance of the microenvironment is attested to by the fact that some 68 percent of the total time of urban adults, on the average, is spent at home. The figure is 76 percent for the total urban population." Perloff, THE QUALITY OF THE URBAN ENVIRONMENT, Washington, D.C.: Resources for the Future, Inc., 1969, p. 19-20.

15. Mort Isler, at the Urban Institute, has this point by aptly suggestion that we define the purposes of national housing policy as the provision of "adequate housing services," rather than just "a decent home," for every American family. This concept of housing "services" deserves to come into general use. See "The Goals of Housing Subsidy Programs," in Papers Submitted to Subcommittee on Housing Panels, Committee on Banking and Currency, House of Representatives, June 1971, pp. 415ff.

16. op. cit., pp. xii-xiii.

9: SPECIFYING AND MAINTAINING ENVIRONMENTAL PERFORMANCE STANDARDS

THE ROLE OF RESEARCH IN THE DEVELOPMENT OF PERFORMANCE STANDARDS

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Abstract

The assumptions underlying much of the current discussion about industrialized building systems for housing are that research should investigate the needs of users of housing, that the resulting findings could be cast into explicit performance standards or specifications to permit industry the development and mass-production of housing systems conforming to these standards.

These assumptions are questioned. If user requirements research is to produce useful results it must focus upon users in actual decision-making situations and be complemented with procedures of negotiation, conflict-detection, argumentation, debate, bargaining and conflict-settling.

An approach is discussed which extends research into the implementation phase of actual projects as a part of the planning discourse and decision making process.

1. Introduction

The development of industrialized building systems for the housing sector is entering into a new phase of large-scale corporate efforts transgressing the traditional building industry, aiming at large aggregated markets and integrated systems embracing structure-enclosure, interior finishings, installations, utilities and including the public services of new communities. At the same time, the government becomes an active participant in this area, in part called for by industry to help carry the development burdens and to guarantee the necessary market site, but, in fact, trying to govern and control the development on its own, providing the framework for industry's activity, striving to secure quality and safety standards as well as taking on the unrewarding task of trying to control the social implications of the housing problem which industry is, understandably, inclined to ignore.

This development means that at many levels people who are usually not directly concerned with the problems they are dealing with must make unprecedentedly far-reaching decisions. For these decisions, criteria which traditionally have been applied to single buildings or projects with familiar techniques are no longer satisfactory.

It is, therefore, not surprising that those in industry and government faced with such decisions should raise a call for better guidelines, better criteria and decision rules. The discussion has increasingly concentrated on what is called the "performance concept" or performance specifications. These can be interpreted as a set of statements which (while not prescribing specific materials, products or technologies) permit a decision-maker to deduce in each specific case whether a product or system is acceptable or not, or to judge which of a set of proposed alternatives is most desirable.

It is quite understandable that the call should be on research to produce the information on which these performance standards might be based. More specifically; the contention is that the standards should be derived from the needs of the prospective users of a system in question.

2. Expectations

It is necessary to take a closer look at this call for Research. In a rather simplified way, the expectations could be described as follows:

- Scientific investigations should be conducted to find out what users of housing, for example, need with respect to the properties of their built environment. Here, one quite readily admits the existence of different user groups, say with respect to age, income, life style (a euphemism for "race"?) and that their respective needs might be different;

- The outcome of such research (presumably neutral, objective and unquestionable "facts") should be stated in terms of unequivocal user needs requirements. Preferably, this should take the form of lists of variables which can be easily quantified and measured, to allow verification in specific cases, so that decisions are not likely to be questioned afterwards because of conceptual vagueness or uncertainty about the actual quantities of a given solution: "No useless discussion.

- Now, the standards of performance would be

- set, according to the research findings, as values or ranges of values on the variables.

- With these prerequisites, industry could develop building systems to meet the prescribed performance standards - or also present their systems for testing and evaluation (but against criteria known beforehand). This would take the burden of responsibility off everyone - industry would be free to develop technical solutions to well-specified problems - efficiency in meeting the specifications would be their sole concern - and government officials would just have to verify (measure) whether a given item conforms to the standard.

3. Questions

Are the preceding expectations and assumptions realistic?

Well aware of the risk of being accused of posing unreasonable demands and thereby hampering what little and bitterly necessary progress we can achieve, it is our contention that they are not only unrealistic but that they represent a step in the wrong direction. There are a number of reasons for this: the first, and probably most important, rests in the concept of user needs. While it sounds quite sound, if not inevitable (and what is more, popular from left to right) to base developments of building systems upon user needs - what else? - the attempt to state these needs often turns out quite narrow, abstract statements based on trivial physiological conditions. These do not provide sufficient power to distinguish between even crude technologies. In the process of more discriminating specification - a number of disturbing properties are found:

- "user needs" change over time,i.e. these requirements are not sufficiently stable even within the same individual to permit an unequivocal statement that such and such must be the case;

- this, of course, is because (as mentioned earlier) people are different with resulting differences in their "needs" and do change from one identifiable group to another. Some transitions are automatic, such as ageing - others are spurious, random, voluntary, subject to fac and fashions, and unpredictable.

- "user needs" are dependent on the social context: a person may exhibit quite different "needs" in one society than when he is moved to another; another way of saying the same thing is that they are to a considerable extent dependent on tradition and quite arbitrary conventions. For example, we are used to buildings providing shelter from weather conditions, space, light, water etc. but generally not furniture nor stereo sets nor food, and the possibility that a home might be identical to the means of transportation is still treated as a special case as far as codes, zoning regulations, etc. are concerned.

- "user needs" are technology-dependent. We cannot realistically separate the requirements for building systems from the technological means envisaged to be part of the system. For example, lighting requirements or the simplest sanitary standards of today would have been considered sheer insanity, unreasonable demands in the context of 16th century technology. This is especially critical when we are dealing with innovations: a system of standards implicitly geared to the given technological possibilities becomes a roadblock to significant technological innovation (even if it is granted that performance standards as opposed to product specification do favor improvements on the same technological level. But performance standards for sailboats or horse carriages of the kind aimed at in construction now would never have permitted introduction of the steamship nor the automobile);

- these examples reveal that we should talk about user "ambitions" and "aspirations" rather than "needs";

- Whereas initially one might have started from notions of a contradiction-free, somehow "natural" system of user needs, talking about aspirations makes it quite evident that they may be conflicting, counteracting or mutually exclusive. This means that in a planning case, decisions have to be taken to "resolve" these conflicts, i.e. to strike a balance between them, or decide against one aspiration-need in favor of another.

- It should be equally obvious that such decisions can only be taken on the basis of personal values. But, if this is true, the notion of universally valid performance standards based on what we now would understand by "user needs" cannot be maintained: the setting of a balance - or choice of one of two conflicting objections - is an arbitrary act. This kind of information can only be obtained from the individual user in a specific concrete situation, and the researcher has no scientific nor moral, ethical or political mandate (for we must recognize that we are facing political questions) to make these decisions in lieu of the user or those affected by such decisions. Taking averages of "prevailing" opinions, extending trends of past attitudes, etc., are obviously no viable alternatives, either.

A remark is in order at this point about the common avoidance of such imaginable "needs" as that of the user "needing" to make decisions about his environment himself. If it were admitted that this might be a genuine concern, then there is no justification for assembling an elaborate system of performance standards. This cannot be helped by providing fake "choices" among pre-established alternatives. It should be clear that what is meant is the generation of such alternatives by the user himself. Without falling into extensive philosophical discussions, a strong case can be made for the contention that it is precisely this feature by which man develops and maintains his identity, dignity, self-image. One might say that the areas of self-expression have changed through history - formerly vital means of self-expression have been succeeded by others and left to standardization - why not e.g. housing? But these are questions that cannot be decided upon by research, industry or government - they must be discussed.

This discussion of user aspirations and values shows an emerging dilemma: with respect to technological innovations, the prospective user cannot develop a proper value position and make choices he would - himself - be able to live with - in a void, remote from the actual experience of the impending consequences of a decision. This might well be the reason for so many failures of the "ask the user" approach, which has led to the widespread attitude that "the user does not know what's best for him." It must be maintained that he cannot know if he is merely confronted with abstract alternatives whose consequences he cannot judge adequately and not having any share of responsibility in the decision. But at the same time nobody can know better what consequences should be considered - if he is made to fully understand the alternatives. The problem, of course, is that in many cases the users are not known, and that even if they were, informing them about all possible alternatives and obtaining information useful and significant enough represents an effort generally out of scale to the resources available for most projects.

The second major objection to the idea of a system of performance criteria has to do with the measurability of performance variables - even if we assume that we are considering questions which are not personal judgements. The legitimate but disastrous quest for hard "objective" criteria carries with it the temptation to concentrate upon variables which can be readily me measured and to neglect those which do not lend themselves to easy quantification and verification. It goes without saying that this can lead to severe distortions in evaluation results. But perhaps more critical overall might be the extension of this temptation to research itself. Researchers today are under very much the same pressure as anybody else to produce useful results in short time - and since the field of investigation is at any time more complex and greater than can be handled, it would be only normal to focus upon the easier tasks first. Moreover, there exists in the realm of scientists a distinct distrust of dealing with variables and concepts that are not fully defined, quantified, etc. No matter how important work on such aspects might be, researchers shun tasks for which they might possibly be labeled as "unscientific".

These observations would nourish the suspicion that the models which serve as the working base for research investigations might, on the whole, be equally slanted toward preoccupation with easily quantifiable entities; and it should be obvious that models in which important variables are omitted because one does not know how to measure them are of rather limited usefulness. It should be pointed out that this by no means should be understood as a criticism of models which have been proposed, nor as an accusation of arbitrary, even cynical omission of variables from models in which they should appear, but rather as a suspicion that (though unwittingly) the difficulties outlined influence the very choice of models for investigation.* Here we have another source of error which has been given little attention, and which is of little concern in a single research task, but which becomes extremely critical when seen from the point of view of the effort to develop an overall, coherent, complete set of performance measures and standards for, say, housing.

Third, even if we assume that somehow a set of performance variables has been arrived at and that they, indeed, can be measured, in very few cases will we find that there is precisely and only one value of that variable which must be achieved. An acceptable range of values will probably be the normal case, or also all values below or above a certain point will be acceptable. This does not present a great obstacle to the evaluation of alternatives, since of two different values one can always be judged as "better" or "more desirable" than the other. (The only difficulty might be in saying "how much better" which is, once more, a problem of value and judgement or in who is to say, but if we are talking about standards, where should the standards be set? It is a commonplace observation that standards which are located close to the minimum acceptable value tend to produce solutions which are just that: barely acceptable. But deviating from that minimum usually costs money - how much do we want to pay for higher quality standard? These are, of course, again questions which cannot be resolved by research.

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* On the other hand, it is well known that research results can be bought and produced almost "to order" to fit any political purpose but that is a question of ethics in research which is not our concern at this time.

The preceding considerations have shown that the role of research must be viewed with some caution, and that it is least useful in that area that industry and administration would like most - the alleviation of responsibility for their decisions. Furthermore, some of the difficulties make performance standards appear as less of a solution to our troubles than much of the recent discussion would indicate.

This does not mean, of course, that either research efforts should be abandoned nor the efforts to develop performance measures should be diminished. But their respective uses and roles within developments such as that of industrialized solutions to the housing problem must be redefined.

4. What is Needed?

The following suggestions may serve as a first step toward an outline of what we need:

Performance Measures

To begin with performance measures and statements as the objective of research efforts. In our opinion, these should not be considered as an ultimately "complete" set of standards to which all decisions could be referred, but rather as a frame of reference for the discussion which undoubtedly will go on for a long time. The rationalization for decisions to develop or support the development of particular systems, and finally to implement such systems, must be sought elsewhere.

Research

If the above contention is correct - that some of the critical information needed consists of user's value attitudes and judgement, and that people can develop such judgement only when confronted with the real choices and responsibility for the decision, then research must focus upon users in such decision-making situations both in studying and assisting them. This amounts to saying that:

- we need alternate models of the planning and decision-making process;
- the prospective users must play a significant role in that process;
- therefore, probably, the overall picture should not be "nation-wide" centralized projects in which the decisions must necessarily be abstract, geared to (lowest?) common denominators and remote from their consequences; but a variety of projects which may be centrally coordinated in a network where decision-makers will be in very close touch with the real implications of their planning;
- research must be integrated into such planning processes. This means that research should no longer be conducted before a project starts, then withdrawn to leave those concerned with results often quite far from what they actually need. The direction of the research should be governed by the problems and questions actually occurring during the course of a project. It is obvious that this demand will be difficult to meet. It will conflict most severely with traditional independence and working style of researchers, and it will create problems of logistics and coordination as it attempts to provide research services to be drawn upon when necessary.
- Nevertheless, research itself should not be expected - nor allowed - to provide answers where it is - as research - not entitled to do so. That is, in all questions that fall into the domain of value judgement, personal preference, decisions among conflicting interests and objectives, compromises, etc.
- This finally means that research must be complemented with procedures of negotiation: conflict-detection, argumentation, debate, bargaining, conflict-settling. This should not be considered a - perhaps necessary - evil, but as the very process of planning; a vital source of design decision criteria. Research findings and professional technical expertise contribute to the forming of the opinion and judgement of the decision-makers, but do not substitute for it.

5. Proposals and Approaches

These are some of the things we need. Do we have the means for organizing such planning processes?

The problem of integrating research activities and research findings, reference to existing standards, codes, etc., professional expertise and interests, opinions, judgements of those concerned by a project can be viewed as an information system problem.

Work has been done recently[1] on information systems which are planned specifically to support planning processes of various kinds: Issue Based Information Systems ("IBIS") are based on a model of the planning process as an argumentative discourse during which issues are raised (e.g. what should be achieved, etc.) and debated because the participants in the discourse assume different positions with respect to these: for, against a proposed measure. Arguments are offered to back up the positions assumed or to refute counterarguments, this leading to new issues as the debate proceeds. In this play and counterplay of issues and arguments questions of fact, or explanation of definitions, causal connections or functional relationships as well as instrumental questions (how to do, achieve certain objectives technically or methodically) occur and must be answered to validate arguments. This is the task of research and professional expertise.

By choosing issues and questions as the elements or organizing principle of the information system, a very precise picture of the state of the discourse can be conveyed constantly to all parties involved in such a process - specifically to the aspects of research which are our main interest here, so that investigations may focus exactly on what is needed for the case at hand.

Arguments typically contain, implicitly, criteria for evaluation of solutions for the planning problem. Experience shows that this source of criteria is a much richer one and generates a much more differentiated discussion than pre-established evaluation systems starting from abstract categories such as "costs", "benefits", "risks", etc. To each evaluation aspect, generally a number of variables and indicators can be associated which may serve as performance measures for any resulting solution. Choosing among these variables again is, in itself, an issue to be dealt with critically, (since measurements and verification not only involve expenditures of resources but also influence, especially in social systems, the solution itself.) Measurement and verification, development and manipulation of models to predict the expected performance of a solution with respect to the aspect under consideration is again a matter for research and professional experts. Their business is not, however, to determine the weight an aspect should carry in the final decision about a plan.

The outcome of such a process will show that whatever performance standards may have been developed a priori will never provide sufficient information for decisions to be taken in particular planning situations - they may or may not carry more weight than aspects arising specifically from that situation. This is the reason why standards should not be considered more than a frame of reference to be constantly improved, amended and supplemented in each single case as may be necessary. It is evident that if the standards in this way lose their traditional role of legitimization of decisions, these can only be legitimized by distributing the decision-making responsibility as widely as possible - gaining accomplices to share the risk and consequences.

Based on such considerations and techniques, some approaches have been developed for the organization of projects (planning and research projects) which attempt to account for some of the demands outlined earlier. As an example, a proposal shall be discussed briefly which was developed for a project in Germany. The task was to survey, evaluate, recommend improvements for, and organize the implementation of prototypes of various "urban systems" proposals. This was a first major attempt to include a number of such proposals put forward during recent years (ranging from building systems, technical innovations for use in urban design, to major innovative concepts for the form and organization of cities) into the current practical discussions about urban design in Germany.

In contrast to the official proposal which was eventually given the contract[2], this concept [3] abandons the idea of extensive theoretical investigations prior to implementation and separate from actual projects. An attempt is made to introduce the proposals in question into actual ongoing urban planning projects in various places at a very early stage, to initiate what was called a "Structured Planning Discourse" (for lack of a better name) in each project, which would be supported by an IBIS-type planning information system and whose aim it would be to record very carefully the resulting discussions. The SPD would be organized in several distinct cycles, each with a very definite task to be fulfilled (e.g. selection of a site, spelling out and preparing the conditions for a competition, evaluating the entries and taking a decision on the alternatives, etc.) and each carried out with as much participation from prospective users and the public as possible.

In preparation for each cycle, a research staff would investigate "model issues" likely to be brought up and organizing what contributions could be found in the literature and other cases.

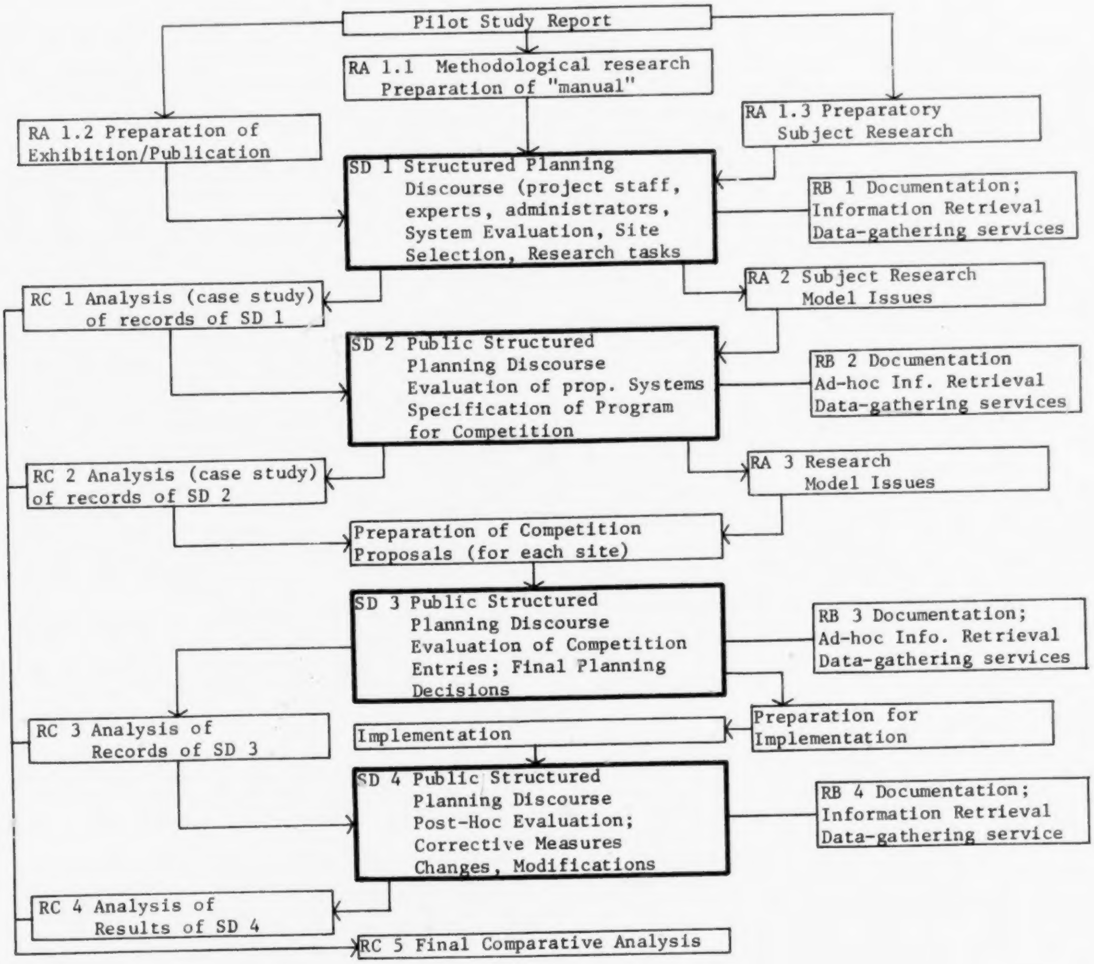
During the discourse cycle itself, research assistance would be required to provide fast and expedient expertise and information on issues and questions brought up by the participants.

Subsequently an analysis of the results of the discourse would be performed and compared with results at other sites. Thus, several elements of a project in which research and planning are integrated in the way described, can be distinguished, as shown in the diagram: SD - the various cycles of the Structured Discourse; and RA, RB, RC, the various phases of research: preparation for the discourse cycle, activities supporting it, and subsequent analysis, respectively.

The advantages of such a project organization (besides corresponding to the demands outlined above) are seen:

1. In the openness of the models which serve as the basis for the planning process and for research, as well as the organization of the information system supporting both.

2. In the possibility of comparing a very rich empirical data base for the investigation of such questions as: Which aspects and problems are recurring in all projects and which ones are specific to the respective particular site and situation? What is their relative weight in the decisions that were taken in each project? From this, some information might be expected as to which solutions and performance criteria may be standardized for future projects, and which ones may not. Of course, the same considerations pertain to the questions of values and objectives (and their stability over time), as well as technological solutions, methods, etc.


Pilot Study Report
RA 1.1 Methodological research
Preparation of "manual"
RA 1.2 Preparation of
Exhibition/Publication
RA 1.3 Preparatory
Subject Research
SD 1 Structured Planning
Discourse (project staff,
experts, administrators,
System Evaluation, Site
Selection, Research tasks
RB 1 Documentation;
Information Retrieval
Data-gathering services
RC 1 Analysis (case study)
of records of SD 1
RA 2 Subject Research
Model Issues
SD 2 Public Structured
Planning Discourse
Evaluation of prop. Systems
Specification of Program
for Competition
RB 2 Documentation
Ad-hoc Inf. Retrieval
Data-gathering services
RC 2 Analysis (case study)
of records of SD 2
RA 3 Research
Model Issues
Preparation of Competition
Proposals (for each site)
SD 3 Public Structured
Planning Discourse
Evaluation of Competition
Entries; Final Planning
Decisions
RB 3 Documentation;
Ad-hoc Info. Retrieval
Data-gathering services
RC 3 Analysis of
Records of SD 3
Implementation
Preparation for
Implementation
SD 4 Public Structured
Planning Discourse
Post-Hoc Evaluation;
Corrective Measures
Changes, Modifications
RB 4 Documentation;
Information Retrieval
Data-gathering service
RC 4 Analysis of
Results of SD 4
RC 5 Final Comparative Analysis

6. Conclusion

As can be seen from the last few remarks, our contention is that the model prescribed for the example could be easily adampted - and should be - for use in further research toward performance measures for industrialized housing systems and similar developments.

There are still many open question in the development of the tools described. One of them is the validity of the assumption upon which the model rests: that the participants (or opponents) in a planning project be willing to cooperate by communicating, by talking with each other about what each one perceives as the essential problems. Other questions pertain to the different role and mode of operation of the research staff within such projects, or the appropriate rule system for the treatment, negotiation, and deciding upon issues.

However, it is held that the refinement of the techniques underlies the same principles as the tasks they will be used for: the appropriate solutions will emerge by putting them to work and adapting the method to the problems as they occur - not by trying to anticipate all possible aspects and developing a fixed, perfected solution that turns out too inflexible to adapt to unanticipated obstacles.

Notes

[1] Kunz, Werner, and Horst Rittel: "Issues as Elements of Information Systems", Center for Planning and Development Research, University of California, Berkeley, working paper #131, 1970.

[2] Stoeber, Gerhard J., "Staedtebauliche Integrations-Systeme" Pilot Study, unpublished, summary in "Staedtebauliche Forschung, Kurfassungen, " May 1971 (Research projects sponsored by the German Ministry of Urban Development and Housing.)

[3] Presented in greater detail in: Mann, Thorbjoern: 'New Approaches for the Role of Research and Information in Planning," working paper, Berkeley, February 1971.

COMPARATIVE EFFECTIVENESS OF DESIGN REVIEW IN WESTERN EUROPE

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Design review, as a regulatory tool for improving the visual quality of the environment, is relatively new in the US but is being adopted by an increasing number of cities. In spite of its popularity, frequent criticism of its effectiveness is heard. This study explores the functioning and structure of a variety of well established Western European programs in order to gain insights into their structure, behavior and effectiveness.

Because the comparative output of such organizations cannot be viably measured, a systems-model was developed from formal organizational theory for this purpose. (1) To achieve its goals a design review organization must first make effective decisions, and second, exercise sufficient influence to implement those decisions. Hence effectiveness was defined as the degree to which the organization as a decision making and compliance structure is capable of achieving its goals without creating undue strain within the constraints of the political culture.

Integrating Simons' concepts for allocating issues based on ends-means chains with Thompson and Tuden's related strategy for delegating such issues to effective decisionmakers, a decision model was developed as an index of ability to make sound decisions. (2) The model outlines a hierarchical structure appropriate for making decisions which have been congruently organized on the basis of their value-fact, ends-means content. It describes the characteristics and competencies of the various decisionmakers and the relationships which should exist if effective decisions are to be made.

Using concepts of effective influence within organizations developed by Etzioni, Schermerhorn and Blau and Scott, a compliance structure model was developed to serve as an index of the organization's ability to maintain the decision structure and to implement its decisions. (3) The model presents a set of effective participant characteristics and relationships based upon the nature of the organization's goals and the emotional orientation of the participants. It describes the forms of power which are embodied in the legislative and administrative ranks and the power involvement relationships which must exist between the participants. Satisfaction of the participants was viewed as a third measure, essentially as a control on the validity of the models, but only when its presence or absence could be explained by political culture variables.

The rationale postulates that organizations whose decision and compliance structures are congruent with the models achieve potential effectiveness and the participants will manifest little or no strain. When these components are incongruent, the organization will be less effective and the participants will exhibit dissatisfaction. Such organizations will indicate a shift, or tendency to shift, toward congruency unless constrained by political culture variables.

Overview of the Organizational Structures.(4)

Sweden. Design control is exercised in selected areas thru detailed town plans which may specify exact building location, shape, height, color, etc. Design review of all buildings in the municipality is implemented under extremely general laws which provide significant discretion to the authorities. The building committee of the city council, working with the city architect, develops and defines goals, policies and standards for review. It is formally authorized to approve projects with the advice of the city architect but in practice delegates this authority to the administrator.

Holland. National law provides broad powers to the local councils. The mayor and council have the authority to regulate the appearance of buildings per se and their relationship to the townscape and to determine reasonable standards for acceptance. This power is usually vested in the executive committee of the council. Detailed town plans are developed to prevent unharmonious visual development. All building in the municipality is regulated under design review powers. The program is administered by the city architect with the aid of advisory panels, required by law. Supervisors are used to coordinate design in areas with development plans.

Denmark. Municipalities are required to prepare detailed town plans which usually contain provisions with respect to the appearance of buildings. Local magistraten (executive committee of the council) may refuse any building, fence sign, etc. which in their opinion is not decent in appearance with respect to the townscape. They may require special form or color in order to achieve such harmony. They are required to appoint a building committee made up of a mayor, architectural and planning professionals, and adminster the program thru the city architect-planner.

Germany. Local councils adopt detailed town plans, but of considerably greater specificity than in the preceding countries. Virtually all construction is regulated as to appearance and its relationship to the townscape, both thru the provisions of specific by-laws and thru general provisions for appearance. Buildings are required to be unobjectionable in their form, mass, scale, and the interrelationships of their masses and parts, materials and color. They are not to be disturbing to the appearance of the street-, town- or landscape, and special care must be given in areas of special visual or cultural significance. The legislation requires that judgment as to adequacy shall be exercised by persons with expert knowledge and experience in design. Expert advisory panels are permitted.

Local administration is relatively simple, taking two basic forms. In Stuttgart, for example, design controls are administered by the city building director who determines policy and develops detailed town plans for the entire city. Day-to-day tasks are carried out by district inspectors. In Düsseldorf, for example, design review is administered by the city architect and a staff of architects functioning solely in design review. An advisory panel of distinguished architects is employed.

Great Britain. National legislation is broad and vague. It grants virtually unrestricted control of building appearance to the local councils, constrained only by the requirement of reasonablesness, that to be determined by esthetically aware and sophisticated persons. The national government has made no attempt to define these powers except as takes place in the responses to appeals at that level.

Design review at the local level is carried out thru the planning committee of the city council. In most cases, it does not attempt to define objectives, policy, or standards for community appearance or review. Administration is usually carried out by a planning officer. In most cases, the planning officer fails to provide additional clarification of the program. All building is reviewed, with considerable attention given to detail, by the planning officer or his staff. In many cases the advice of his citizen panel is sought.

Findings and Analysis: The Decision Structure.

The Role of the Legislative Body. The legislative body should establish and explicate the general as well as the design values and goals of the community. It should make all highly value-premised esthetic as well as non-esthetic decisions. It must communicate these to the administrative units and make certain that they operate within the value and goal sets established. It resolves lower-order issues involving values but is not competent to make decisions on means.

Sweden, Denmark and Holland. The legislative bodies show relatively close adherence to the model. At both the central and local levels, they articulate public goals, policies and respective value sets which are in turn communicated to the administrative units through the local legislative or executive committees. These values are carefully enforced by the legislative bodies, who maintain close contact with and cognizance of administrative activities. This is somewhat less true of Sweden where the legislation is less specific, the value set vaguer, and participation by the members of the legislative body less direct than in Denmark or Holland.

For the most part, the local councils resolve all issues involving major esthetic values or between esthetic and other basic values. They review all administrative decisions, function as an appeal body, and positively intervene when disparities in administrative activities are observed. Holland and Denmark also require that all dissenting decisions, rejections and controversial issues be reviewed at the legislative level.

In all three cases, the legislative bodies limit their activities to the above areas and avoid interfering in the area of administrative competency. They do not involve themselves in project decisions except where these involve conflicts between esthetic and non-esthetic values, and, in these cases, seldom substitute their esthetic judgment for that of the administration.

Great Britain. Although there is considerable variety in administration in Great Britain, in general the behavior of the legislative body departs significantly from the model. The central government has developed only very broad and general guides for policy and values with respect to architectural control. While the Ministry clarifies its policies through advisory statements, it has not enforced these except on a project appeal.

In turn, local councils do not specify values or policies. While they do resolve value issues, they absorb the decision-making function of the administration, making most decisions on means requiring esthetic expertise as well. Although all decisions are made by a single body, presumably with a consistent value set, the failure to articulate this value set results in capricious and ineffective decisions on means and a lack of value congruence in the organization.

Germany. Policies, goals and values of the central and state governments have been specifically articulated. State legislation in particular has been extremely specific with respect to the importance of esthetics both as a value and as to criteria for acceptability and judgment.

Beyond the enacting of specific bylaws clearly establishing local policy, the local councils in Germany play an extremely passive role. They have delegated virtually complete decision-making authority to the bureaucracy, abdicating to it the solution of issues involving values as well as means. They do not even enforce those values and criteria which they stipulate.

The General Administrative Role. The model specifies that administrators should make decisions and resolve issues within the framework of values and policies articulated by the legislative body, and provide information to them with respect to these activities. A panel of design experts is competent to make decisions on means which are premised on a mixture of values and facts and are synthetic in complexity involving an almost infinite number of concepts and a complete spectrum of possible solutions. The role of the administrator with design expertise is to resolve issues which are highly fact premised and less complex but which nevertheless require judgment and design expertise. Persons without design expertise can only function in completely programmed, or fact, situations.

Holland, Denmark and Sweden. The administration makes all means decisions within the framework of established values. It is the final arbiter of decisions on esthetic means and is not permitted to resolve issues premised on basic values, esthetic or otherwise.

Germany. Administrators commonly make basic value decisions outside their prescribed competency and inconsistent with the value set articulated by the councils. They often resolve conflicts between esthetic and other basic values, as for example, tradeoffs of technical and economic factors for esthetic ones. In some cases, administrators not only employ standards of acceptability and judgment inconsistent with legislative policy but also use powers to enforce these which are inconsistent with constitution.

Great Britain. Planning officers and advisory panels make virtually no decisions on values. Means decisions are often disregarded by the legislative planning committees, who substitute their esthetic judgment for that of the administration acting as de facto decisionmakers.

The Administrative Decision-Structure. Further analysis of the administrative function is necessary to determine if the means decisions are allocated to the administrative body most competent to make the specific types of decisions.

Düsseldorf. Administration in this city is congruent with the model. Applications are initially processed by staff members who are esthetic experts rather than generalists. They are in turn reviewed by the expert advisory committee (1) if the project is being considered for formal rejection; (2) if an issue arises of such complexity that it cannot be resolved by the staff or when additional expertise is desired; or (3) if the project is well designed but improvements are still desired. In this manner, decisions requiring greater expertise and group judgment are allocated to the competent advisory panel, while routine decisions are processed by the staff members. Formal coordination of the process is accomplished by the building director who, in addition to functioning as a staff decision maker, determines the allocation of projects to the advisory panel. The recommendation of the advisory panel is accepted as the ultimate decision, thereby enhancing the influence of that group.

Holland. The administrative pattern in most Dutch cities is conceptually almost identical to that of Düsseldorf. In Amsterdam, which deviates slightly, routine transactions are processed by advisory bodies of experts rather than bureaucratic experts. For the other two major components of the model, however, Amsterdam's experience is congruent with the model. Complicated projects, significant issues, and problems requiring greater expertise or breadth of judgment are processed by a group of experts, and the ultimate formal administrative tasks are transacted by the director of public works. The hierarchical structure of committees, divided with respect to the nature of the project or project area, results in a narrower substantive scope and greater expertise than would be the case under a single committee.

In the newly developing areas of Amsterdam supervisors are employed, who are practicing architects. An additional lower-order set of more specific objectives are created as guides for the supervisor, but complex decisions are made by the advisory committees. The supervisor is simply added to the administrative structure at the lower level.

Dutch cities have commonly employed advisory committees of the most highly regarded and capable professionals who are relied on for handling the day to day project evaluations. In addition, the cities employ highly expert and respected bureaucrats by engaging these persons not only as administrators but as the design architects for municipal projects.

Stuttgart, Sweden and Denmark. Stuttgart functions entirely through staff members. Regardless of their complexity, projects are delegated directly to the local building inspector, a civil servant trained in design. Significant issues, complex problems and routine matters are all administered by him. While the building inspector is competent to resolve judgmental problems, he has neither the degree of expertise nor the breadth of an expert group to effectively resolve the synthetical and more value laden issues.

In both Sweden and Denmark, all administrative decisions are made at a central office by bureaucrats. As in Stuttgart, no provision is made for an expert advisory group to resolve synthetic and value laden means decisions. Administrators in these three cases are trained and function as architectural generalists rather than as esthetic specialists. Hence their expertise in esthetic matters is normally less than in Holland or Düsseldorf where esthetic specialists are employed. Although there is considerably more emphasis in Sweden in attracting personnel who are respected by their professional colleagues, even these persons are neither as highly nor as uniformly respected as are the members of the advisory committees of Holland and Düsseldorf.

Great Britain. The almost total monopoly of decision-making by the local legislative bodies makes the British administrative decision-structure deviate most from the model. While the administrative components of the model exist, they are not effectively employed. Where advisory panels are used, the members are usually laymen or mediocre architects not highly respected by their professional colleagues. Although there are exceptions, planning officials tend to be untrained in design as well.

Comparative Evaluation. On the basis of the above, the organizations are ranked as follows:

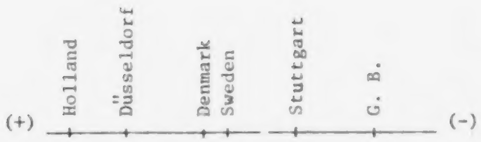

Fig. 1-- Congruence of Decision-Making Structures with the Model

Findings and Analysis: The Compliance Structure.

Analysis of Compliance Relationships. The model states that the legislative body, as formal leaders, can maintain remunerative power over the expert administrator, normative power over the expert collegium and coercive power over alienated applicants. The panel of experts should not be bureaucrats. They should be informal leaders who manifest normative power based upon their professional expertise and and status as well as remunerative power based upon their design expertise. They should exercise leadership in issues with morally involved applicants and use remunerative power with calculative applicants, except in conditions of continuing relationships. Individual experts should be formal leaders, i.e., bureaucrats, whose rewards are primarily remunerative. They will have limited normative power but significant remunerative power derived from both professional expertise and their bureaucratic position. This is effective with calculative applicants, especially so in continuing relationships. Based upon their official position, expert bureaucrats should have coercive power over applicants opposed to the organization's means or goals.

Denmark. Because of the belief in democratic principles and a conviction that design quality in Denmark is generally good, the exercise of power by the authorities in Denmark is extremely limited. They have legal status but no legal power and lack the normative power derived from panels of experts. Hence, potential power is confined to that which the city architect achieves from his official position, expertise and status. The city architect's expertise and status, however, are extremely limited and constrain his potential influence. As a result, design review in Denmark is only effective with calculative applicants, i.e., those amenable to remuneration.

Given these limitations, the small but noteworthy impact which Danish architectural control achieves results from an appropriate use of the limited power over a select group of applicants. Because community appearance is not perceived as a significant problem, the administration has limited the organization's boundaries to achieve a congruency between the available power and the applicants it strives to influence. As a result, there is no reason to anticipate that strain exists in other applicants; it does not because control does not exist.

Holland. While coercion through legal sanctions is permitted in Holland, it is seldom employed. Instead, administrators use normative power supplemented with extensive remunerative influence derived from providing advice, service and information to applicants. Council members, as formal leaders, exercise ultimate coercive power over alienated applicants and remunerative power over bureaucratic members. They indirectly exercise normative power over the expert panel by consistently upholding and implementing their esthetic judgment. Both the director of public works and the city architect, as formal leaders, have significant remunerative power over calculative applicants. In addition, the city architect, as a continuing practitioner with professional status, has significant normative power over morally committed applicants. The expert committees, made up of highly respected and expert practitioners, provide the administration with extensive normative and remunerative power, as do the supervisors employed in development areas. The latter work closely with small groups of applicants for an extended period of time, developing a continuing relationship with the applicants which increases their remunerative power.

The administration attempts to assign applicants to the most effective decision unit and source of power. Issues are delegated by the professional subcommittees of the advisory panel, based upon the complexity of the decision and the emotional orientation of the applicant, to the committee or individual most capable of implementation. When an issue cannot be resolved it is reassigned to a group with greater normative and remunerative powers. If it cannot be satisfactorily resolved in this way, the issue is referred to the council for exercise of legal sanctions. Coupled with the extensive remunerative rewards provided to the individual practitioners and the design profession as a whole, this results in a design review program which exerts significant influence.

Düsseldorf. The compliance relationships in this city are similar to those in Holland. Coercion is only employed where absolutely necessary; normative plus extensive remunerative power provide the basis of influence over the applicants. The city council permits both the expert committee and the staff to achieve symbolic satisfaction from their participation, and the city architect, by confirming and implementing all decisions of the expert advisory committee, maximizes the symbolic satisfactions of the committee.

Potential power is effectively used. The city architect and his staff of design experts process routine projects submitted by calculative applicants. Issues involving architects of high professional status and moral involvement are delegated to the expert panel, constituted of the most respected professionals in the area. In cases where greater normative or remunerative power is needed, the expert committee deals directly with the applicant. This practice enhances the staff's continuing relationships with applicants and minimizes a reputation of a bureaucratic ogre. The compliance structure is highly congruent with the model, only slightly exceeded in this dimension by that of Holland.

Stuttgart. All applicants are processed by the district building inspector whose expertise and professional status is extremely low, and leadership is virtually non-esixtent. He is limited to the coercive power vested in legal sanctions and remunerative power based upon his position. His remunerative power is derived primarily from the manipulation of technical requirements. These forms of power are perceived as illegitimate by the morally involved applicants and are alienating to them.

The inspector attempts to expand his coercive power by employing standards of acceptability and judgment more specific and rigorous than those permitted by law. This use of illegitimate power is recognized by many applicants and alienates rather than develops useful cooperative working relationships with them. Given the existence of pervasive moral involvement among applicants, these means partially explain the pervasive applicant strain and dissatisfaction which exists.

Sweden. The city council maintains remunerative and normative power over the city architect and his staff, the latter by allocating to them jurisdiction in decisions involving esthetic expertise. All projects are reviewed by the city architect whose coercive power is minimal. While he is more highly respected and his remunerative power is greater than that of his counterparts in Denmark and Stuttgart, it is less than that of the expert advisory committees.

Legal sanctions are virtually never employed in Sweden. The administration depends primarily upon remunerative power and, to a lesser degree, upon leadership. An indication of the ineffectiveness of this with morally involved designers is expressed in the desire of the applicants to have more expert and respected administrators and to have institutionalized patterns of communication with the administration.

Although the lack of a significant source of normative power limits the administration's influence, the city architect maximizes his remunerative power by providing extensive service and information to the applicants. This, coupled with his respect for the most prestigious designers, serves to maintain a positive emotional situation.

Great Britain. Council control of the administration is uniquely remunerative; no normative power is exercised. In substituting their esthetic judgment for the administration's, the planning committees do not provide the symbolic rewards to the administration or the advisory panels. Since the panel members primarily serve because of moral involvement and the planning officers often do so in part, the non-congruent compliance relationship partially accounts for the dissatisfaction manifested and for the difficulty in employing highly expert persons.

Power over applicants is exercised predominantly by the planning committees. As legislative members without design expertise, they are limited primarily to legal sanctions. In practice, they expand their influence by imposing illegitimate legal sanctions. This practice results in alienating applicants not only because it is perceived as illegitimate but because the planning committees lack expertise and normative influence.

Where planning officers are used, they are essentially ineffective. They frequently are not trained in design and are confined to employing coercion and limited remuneration. In the few cases where planning officers who are trained in design make the esthetic decisions, effectiveness is vitiated by their lack of professional status. Similarly, the advisory panels have limited power. Lacking significant stature in the profession, they have little normative power. Lacking outstanding expertise and being reluctant to provide advice and service to the applicants, they have ineffectual remunerative influence. By adhering to the practice of rejecting or accepting proposals, they limit their power to coercion. As a consequence, coercion through the use of legal sanctions is prevalent and creates pervasive and intense dissatisfaction.

Comparative Ranking. The examples may be ranked with respect to their congruence with the compliance structure. (See Figure 2)

Political Culture Characteristics

The political culture helps to explain model deviations, effects and resistance to adaption.

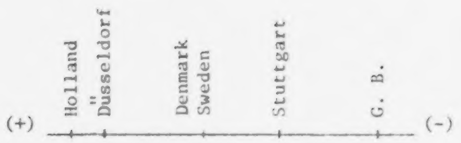

Fig. 2--Congruency of Compliance Structures with the Model

Germany. The German ascribes significant status to bureaucrats and has a strong propensity for obeying their commands, whether or not he regards them as legitimate. Conversely, the bureaucrat expects his orders to be obeyed. He is extremely reluctant to participate actively in government or try to influence it. These culture characteristics, combined with the costs of appeals, which are high in time and money, limit overt manifestations of strain and, in its presence, can vitiate the effectiveness of the appeal system as a vehicle of change.

Great Britain. The Briton views the bureaucrat as a servant, ascribes low status to him, and is extremely willing to challenge bureaucratic decisions and appeal. The great number of appeals and decisions overturned by appeal indicates that extensive dissatisfaction. However, they can only partly overcome the extreme temporal and economic costs in appealing and only the most morally involved applicants without significant constraints on time or money will do so.

Denmark. The Dane considers the administrator a public servant and is not reluctant to appeal bureaucratic decisions. Opportunities for appeal to an Ombudsman and to the Crown are most convenient. While the political culture is not as extreme as Great Britain's, manifestations of strain should be evident if the system is ineffective.

Holland. The Dutchman ascribes even more status to the bureaucrat than does the Dane and is generally less willing to appeal bureaucratic decisions. The appeal system in Holland, however, is the most accessible and least costly of the examples studied. If ineffectiveness exists, manifestations of strain should be exhibited.

Sweden. Appeal procedures in Sweden are similar to those in Denmark. The Swede, however, ascribes more status to the bureaucrat than does the Dane or the Netherlander and is less willing to challenge bureaucratic decisions. He is similar to, although not as extreme as, the German in these respects.

Comparative Ranking. The political culture characteristics can be ranked as follows.

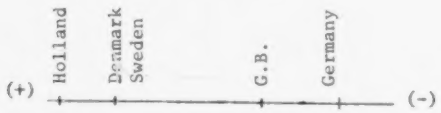

Fig. 3--Structural Conduciveness of the Appeal Process

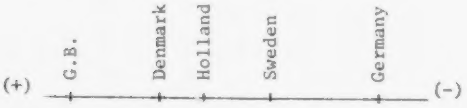

Fig. 4--Willingness to Challenge Bureaucratic Authority and Appeal Bureaucratic Decisions

Participant Strain.

Having ranked the model congruence of respective countries or cities, there is imputed to them a ranking of effectiveness. The participants themselves, however, reflect their own judgment as to the effectiveness of architectural control. If there exists a correlation between effectiveness and strain as suggested in the rationale, then this should be revealed in the responses of the participants, at least within the socio-cultural constraints which may exist.

These responses manifest themselves in a variety of ways, and no greater weight or validity to one or the other has been assigned. The concern is to determine the sense of the participants with respect to the value or worth of the particular architectural control effort with which they are familiar.

Holland. There is in Holland a widespread commitment to the value of architectural control and approval of the system that is employed. The applicants express extreme satisfaction with design review and the benefits it provides to them as individuals and to the profession as a whole. There is no expressed desire to appeal decisions nor is there a record of appeals to the courts of any consequence. The administration, too, expresses widespread satisfaction with the effectiveness of architectural control within the limits which they attach to its potential. In no case is there criticism; there is only the expressed desire for more highly qualified administrators. There is, however, considerable concern over the quality of the environment which is judged to be monotonous. This is primarily attributed to the quality of the designers, however, rather than a result of architectural control.

Düsseldorf. There appears to be a lack of strain and the complete acceptance of architectural control as well as the specific system employed in the city. The administration is convinced that regulation is a valuable aid in improving community appearance. While the architects do not express satisfaction with the program in terms of professional rewards, as was exhibited in Holland, there was no dissatisfaction expressed. There have been no appeals to the council or the courts. On the contrary, there is great satisfaction with the functioning of the advisory panel of experts in this respect.

While better community appearance is still desired, the participants are reasonably satisfied with what exists. Architectural control is judged to be achieving its potential, and further improvements must come from more expert designers. It is significant that Düsseldorf's program has been adopted by other cities in Germany upon the recommendation of the private architects.

Denmark. Many architects are unaware that controls exist nor is there the desire expressed to see them implemented. Those planners and architects, however, who are aware of the process do not perceive significant environmental or professional benefits resulting from its use.

Legislators and the administration express mild dissatisfaction with the scope, rigor, and effectiveness of architectural control. They desire more comprehensive and rigorous application and greater expertise in administration, but believe that this is politically unfeasible in Denmark. On the other hand, the visual quality of the environment is universally judged as good and there is little motivation to implement more rigorous control. In sum, the response is mixed and mild.

Sweden. There is a pervasive belief in the program and satisfaction with it, both in terms of goal achievement and individual professional rewards. The only evidence of strain is expressed in the desire of applicants for greater participation in the process and higher quality administrators who would be more active in the actual practice of design.

The environment is judged of good overall quality but with few outstanding buildings. The participants do not believe, however, that architectural control is basically at fault.

Rather, the quality of community appearance is inherent in the culture and the educational system.

Great Britain. Dissatisfaction is intense. Many applicants are negatively oriented to the means employed as well as alienated to the concept of design review. Others, while continuing to believe in review, are distressed by the coercive and illegitimate means employed. The process is not perceived as providing rewards for the applicants either, in terms of service. It is, however, frequently faulted for eliminating many outstanding designs.

Great Britain is unique. In no other country does there exist alienation between the elite groups. Appeals are plentiful. It is the only example where continued controversy, self analysis, criticism, and changes in policy within the professional society have occurred. In spite of this, the British administrators and professionals are more critical of the quality of their visual environment than is the case in any of the other countries and few participants believe that design review has helped.

Stuttgart. For the most part, but to a lesser degree, the strain manifested in Stuttgart resembles Great Britain. In this city, no alienation occurs within the elite ranks but there is considerable between the administration and the applicants. But while there is considerable disposition to appeal, no appeals occur.

The strain manifested is primarily a response to the means employed rather than to design review per se. The architects and planners believe that it is necessary but perceive the program as it presently operates to be ineffective in improving community appearance and in providing rewards to practitioners or the design professions. On the contrary, many believe that it hinders the development of a beautiful city and is deleterious to good design. In addition, considerable alienation results from the illegitimate use of coercive and remunerative power.

As for the effect of the environment itself, there is considerably less satisfaction than exists, for example, in Sweden but more than in Great Britain.

Comparative Ranking. Synthesizing the above, the various organizations may be ranked with respect to their manifested strain and satisfaction as related to architectural control. (See Figures 5 and 6.)

Conclusions.

The rationale underlying the conceptual framework postulated that organizations whose structures are congruent with the model achieve the potential effectiveness. Little or no strain would be found among the participants. Organizations whose decisionmaking and/or compliance structures are incongruent with the model are ineffective and will indicate symptoms of participant strain. Incongruent organizations would manifest a shift toward more congruent states unless such changes are constrained by characteristics of political culture.

The organizational structure and behavior in Holland is highly congruent with the model and the participants express extreme satisfaction.

Düsseldorf's organizational structure is only slightly less congruent than Holland's but due to the behavior of the administration, this incongruency is essentially neutralized. While no strain is manifested, the satisfaction derived from the program is not quite as high as in Holland. The participants believe that design review potential is being realized.

Sweden's decisionmaking and compliance structures are less congruent with the model than the above. Although there is high commitment to the program itself, there is mild strain specifically related to deviations in the administrative structure from the model. Satisfaction with the environment and the personal and professional rewards derived from design review, together explain the failure to implement changes in the administrative structure toward greater congruency with the model.

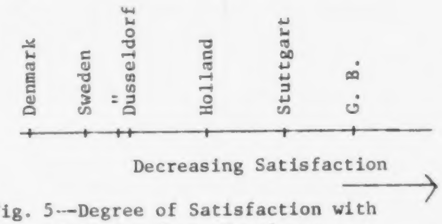

Fig. 5--Degree of Satisfaction with Existing Community Appearance

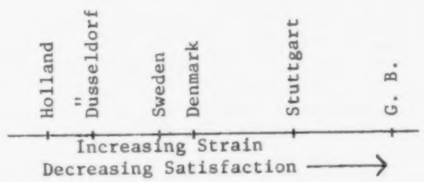

Fig. 6--Degree of Manifested Strain and Satisfaction Caused by Architectural Control

Denmark's limited application of design review is congruent with the model. The political culture is conducive to appeal and modification and if participant strain exists, there should be a tendency toward a more congruent organizational structure. But the strain is restricted to a small portion of the participants, who in addition, are the least likely to implement changes. Since there is significant satisfaction with the environment and a pervasive belief that design review cannot further improve it, it is reasonable to conclude that change would not occur.

Stuttgart's decisionmaking and compliance structures are highly incongruent with the model. Consistent with this, significant strain exists, resulting from ineffective and alienating employment of power and the lack of expertise in decisionmaking. Together with prevalent dissatisfaction with the quality of the environment, a tendency to shift toward model congruency is hypothesized. The recent adoption of a heterogeneous advisory committee to serve at the request of the administration as well as the recent adoption of expert panels by cities similar to Stuttgart, can be interpreted as such a shift. Nevertheless, the constraints of the political culture and the lack of the viable appeal system vitiates further change from being implemented.

Great Britain exhibits the greatest deviation from the model and the most intense and pervasive strain. Unlike the other examples, these conditions are pervasive throughout the ranks. Applicants are least cognizant of rewards in the system and are least satisfied with the visual quality of the environment. Lastly, only in Great Britain has the strain become so significant as to result in alienation from the concept of design review iself.

The expected shift toward model congruency has occurred in part. The evolution and adoption of the advisory panel system, in spite of its relative ineffectiveness, is a recent phenomenon and the panels continue to be adopted. Similarly, their constituency has changed to a more congruent form. In spite of high civic participation in England, however, incongruency and strain have not been eliminated. This can be explained by the political culture, particularly the intense distrust of the bureaucracy by the planning committees as well as the applicants, and the extremely costly appeal system.

On the basis of the data, the various organizations can tentatively be ranked as to effectiveness as follows:

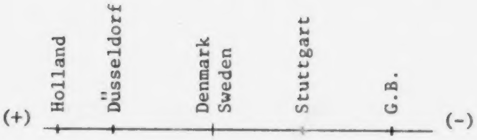

Fig. 7--Rank Ordering of Organizational Effectiveness

Within their limits, the data are consistent with the basic theoretical framework and the concepts posited. The conclusions that legitimately may be drawn at this time are tentative; they are at best a set of hypotheses based upon the concepts of the model which can be used for more rigorous testing other organizational settings.

-Notes-

1. For more detailed development of the models see: Cohn, Sidney. "Architectural Control Organizations in Northern Europe: A Comparative Analysis". Unpublished dissertation: University of North Carolina, Chapel Hill, 1968, Chapter 2.

2. Simon, Herbert. Administrative Behavior. (New York: The Free Press, 1965). Chapters 3, 4; Thompson, J.D. and Arthur Tuden. "Strategies, Structures, and Processes of Organizational Decision," in James D. Thompson, et al, eds., Comparative Studies in Administration (Pittsburgh: University of Pittsburgh Press, 1959) pp.195-216.

3. Etizioni, Amitai. A Comparative Analysis of Complex Organizations (New York: The Free Press, 1961); and Modern Organizations (Englewood Cliffs: Prentice-Hall, 1964); Blau, Peter and Richard Scott. Formal Organizations (San Francisco: Chandler Printing Co., 1962); Schmerhorn, Richard A. Society and Power(New York: Random House, 1965).

4. For more complete presentation of data and methodology, see: Cohn, op cit. Chapters 4-8.

5. For the development of these generalizations, see Uppercue, Charles Q. "A Study of Administrative Authority in Northwestern Europe." Unpublished departmental paper: University of North Carolina, Department of City and Regional Planning, Chapel Hill, 1967.

USER-NEED STUDIES TO IMPROVE BUILDING CODES

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Abstract

The implications of performance, with respect to building codes and architectural practice, are not fully realized. Research, including user-requirement research, is a prime need. These matters are discussed and lead into subject selection, study methods, staff requirements, and other questions relevant to a research program. Examples of user-need research are included.

"User-need" has come to mean, in the author's experience, data and information that replace or supplement the traditional owner's requirements. It means predesign criteria concerning the objectives, activities, special conditions, and demands that a proposed building must satisfy. "Improvement" in building codes connotes an orientation toward performance.

The profound implications of an orientation toward performance have not yet been fully appraised by code-writing agencies nor by specialist groups who would be affected, such as architects. This paper, based on studies for and experience with one model building code which is in wide use, discusses the kind and extent of these implications particularly as they affect architects.

User-need as a subject and user-need studies as a process form an integrated part of the building code approach which results from a performance attitude. Hence a discussion of this attitude and its practical implications is the optimum way of expressing the kind and extent of user-need studies that relate to building code improvement. Not all user-need studies are relevant. It is hoped that the following discussion will clarify the concept of performance and help to define what user-need studies mean with particular reference to code improvement.

The Performance Approach: Meaning and Implications

Converting a building code from specification to performance means more than a clause by clause change. Performance and specification are polar concepts. Therefore, the change to performance transforms the code-writing procedure, the substance of the code, its arrangement, and the means of putting it into effect. Any agency turning to performance must accept a different legal-technical balance in the code, a shift from legal to technical authority, a reordering of jurisdiction, the training and employment of specialist personnel, the development of research facilities, the determination of explicit goals, the restructuring of code form and content, and the acceptance of a code as an 'open' system transcending planning, zoning, building codes and standards.

The architect will be most significantly affected in the area of responsibility. In a real rather than an official sense control will shift to the designer because much of what is now law will become design procedure. The code will be based more on knowledge than on tradition. An important part of the change is to fill gaps in the available knowledge. Some of the largest gaps lie in the field of user-needs, a field which is coming to be of particular interest to architects. Architects will be involved in the information gathering process and setting the standards as well as in the application of these criteria in design.

These developments can be explained by comparing the objectives of the prevailing legal codes that evolved through history with the objectives of codes having a performance orientation. The purpose of legal codes is essentially the same as it was in the 12th century. At that time it was to provide building control with respect to problems that fell outside, or between, the closed professional or trade practice systems. Then as now the architect's concern stopped at the boundaries of his client's property. He is not concerned with the building next door. Law has always filled this gap. It superimposes control with respect to the hazards to adjoining or adjacent buildings. The mason's concern is the chimney and the carpenter's is the house frame. The gap, or lack of gap, where these components come together is a potential hazard. Here again the law steps in.

The performance attitude, on the other hand, must take these gaps into account. Performance can be thought of as an equation. For example, the performance of an exterior wall can be expressed as an equation of the inside and outside conditions. Designers already assume a performance attitude with respect to thermal comfort. It is merely an extension of this idea to add other characteristics such as sound, light, humidity, and also fire, a matter that the law at present rules upon. There is no reason to divide these subjects between design and law.

Performance raises the question of responsibility. Should these subjects be practice or law? The answer for several reasons must be practice. Design standards must be developed in areas that are now controlled by arbitrary legal rules. This requires a commitment to research and standard-making by those who hitherto have relied very largely on experience or intuition, in design.

The gaps, or what needs to be done, are revealed when the broader framework of knowledge for building performance is set down. Three basic categories of knowledge can be distinguished. These are:

1. Knowledge of the natural environment including climate, soils, and earthquake phenomena.
2. Knowledge of the building fabric including properties of materials, functions related to position and shape of members, and energy use, and
3. Knowledge of the controlled environment or user requirements which include all the predesign criteria based on use, such as live and fire loads in addition to requirements for activity space, privacy, and other related matters.

The impetus for research and selection of subject to fill the gaps in knowledge comes from the performance equation. The inclusion of structural design, including material stresses, in codes provided the incentive to verify the assumptions that had to be used to determine live loads, including loads due to use. When fire resistance was introduced, studies of occupancy fire load were inaugurated. When criteria for ventilation, plumbing fixtures and exits were introduced, consideration had to be given to occupant load.

Some of the most definitive work on user-needs has been done by the American Society Heating, Refrigerating and Air-conditioning Engineers and is represented as information provided in the ASHRAE Guide. The stimulus was to provide more accurate information to solve specific heating, cooling, and other problems. A favourable climate for user-need studies exists where a code-writing agency has a building research wing and where the performance equation is acknowledged. Experience shows that in this case the most familiar and persistent code administration problems are due to ambiguity because occupancy categories, which are predesign criteria, are not definitive with respect to the matters that are regulated. The matters regulated usually need study but by far the greatest problem is to define the specific occupancy situations to which these matters should be applied.

Performance and Research Technique

Performance requires that the system of units used for measuring values is suitable to an equation: each must be in the same terms. Live load, material stresses, and shape factors are all expressed in pounds and inches. Fire load and fire resistance are measured in thermal units, occupancy density is expressed in air changes per hour for ventilation purposes and person per minute in a 22-inch exit unit width for exit purposes. However esoteric one may get about user-needs, particularly of a qualitative kind, it must be remembered that these are of value for building control only if it is possible to find some system of measurement or evaluation so that the condition to be achieved (user-need), the condition to be controlled (the hazard), and the means of control (building or equipment) can be expressed in the same terms for equation purposes.

User-need research is often thought to be closely coupled to research in the social sciences, but the integral nature of research for performance codes does not support this image. In the examples quoted the need has been for data gathering and the surveys made have involved simple measurements of material things. The live fire and occupant loads in dining rooms, shoe stores, and warehouses differ due to the different social purposes assigned to the spaces. As long as the spaces can be identified by commonly understood terms, however and there is consistency in the values measured over all the spaces that would be known by the same term it is unnecessary and wasteful to study the activities thoroughly to derive any causal relationships.

Social conditions are changing, however, and building nomenclature is becoming meaningless in terms of the hazards and critical situations that the terms have implied. This changing situation provides an opening for social science studies of the hazard factors of human activities, territories, and belongings as related to building use. Social scientists who are interested in and sufficiently knowledgeable about buildings and their use could make a contribution in this area. The objective would be to identify and describe the critical aspects of occupancy so that reference to ambiguous building-type categories could be avoided. This is a valid area for quality appraisal to distinguish phenomena that are qualitatively different.

In the absence of such interest and expertise steps of a more pragmatic kind can be taken as a temporary expedient. The major difficulty with building codes is with fire requirements. The problems of fire, unlike those of structure, and to a lesser extent health, are related to spaces. Fire occurs in a space and the possibility of identifying the cause and controlling it is indirectly proportional to the size of space. If the space is very large, such as a zone in a city, it will contain a wide variety of activities and a corresponding variety of hazards. Because of this variety no general rule can be devised that controls any one hazard. On the other hand, small spaces, such as rooms, are often devoted to a single activity. Here the hazards are easily defined and controlled. A hopeful sign is that, in Canada at least, the trend is toward regulating smaller spaces. This in itself requires more attention to the definition of occupancy and user needs and is therefore a stimulus for research.

A Proposed User-Need Study

One user-need study which has been projected in Canada and suggested for detailed study has to do with the problem of fire in an enclosed space. Specifically the problem concerns the possibility that occupants may be trapped in a room by a fire in that room which cuts off their means of escape. The classic cure for this problem is to require a second door when the space is more than an arbitrary determined size. This rule has been augmented more recently by flame-spread requirements.

Very little study is necessary to realize that being trapped is not directly related to room size. Also, a second door remote from the first tends to be most impractical with long, narrow rooms, configurations where the possibility of being trapped is the greatest. These problems, arising in building code meetings, have stimulated the research wing to make an alternative proposal. This is to formulate the problem in terms of the functions that relate to the problem directly. The result is as follows:

$$\frac{\text{time for occupants to perceive the danger} + \text{time to evacuate the space}}{\text{time for the fire to cut off escape}} = < 1.$$

When this value is less than 1 (a nondimensional number), the situation is safe.

Several things should be noted about the equation. First, the three functions are all in the same terms - time. Second, all the functions are related to activities in the space. A large number of studies of relevant characteristics of human activity would be necessary before this proposal could replace the contemporary method of regulation. Third, this method shows up the current rules in a new light. At present, the basis of flame-spread controls bears no relationship to occupancy. The number of doors required is related to room size. With the suggested method, flame-spread, doors and many other matters become variables in the formula. More doors or sprinklers could offset higher flame spread or there might be intrinsic user's demands that in themselves would satisfy the equation without the need of any further measures. Finally this proposal relates to what would ordinarily be regarded as esoteric occupancy intangibles but it has been put into terms that can be measured and equated even though more than ordinary reliance will have to be placed on assumptions because of the lack of data.

The author would be glad to exchange information with those who are interested or active in user-requirement research programs specifically oriented toward the development of performance codes.

This is a contribution from the Division of Building Research, National Research Council of Canada, and is published with the approval of the Director of the Division.

DESIGN-ORIENTED APPROACH TO DEVELOPMENTAL NEEDS: An operational framework relating Activity Patterns to Environmental Requirements through the Performance Approach.

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The goal of the designer is the optimization of a viable physical environment that would satisfy and stimulate the developmental needs of the child. To relate design to developmental needs, we must deal with the process of design and the process of development in the same terms (Stringer, 1970).

In this paper we present a heuristic and operational framework in which developmental needs could be stated in design-oriented terms. We propose that developmental needs could be identified and expressed in terms of spatial-related activity patterns, and as such, can be described using the Performance Concept approach, to produce a clear and comprehensive statement of an environmental problem which

- clearly identifies the specific objectives and requirements of the environment to be designed.
- does not inhibit the creative design process, and
- has, inherent in its structure, means of evaluating both the design and the resulting built environment.

CONCEPTUAL DISTINCTIONS

Activity patterns:the means for identifying developmental needs

How can the developmental needs of the child be identified so as to suggest the required performance of the built environment?

If we are to deal with the process of design and the process of development in the same terms, we must open a channel of communication between design and the statement of developmental needs; the psychological private language (Dailey,1969) has to be translated into a design language. To achieve this, we first have to clarify what we mean by development: Hart & Moore (In Press) suggest that the term "development" should be reserved for the "... qualitative changes in the structural organization of behavior..." Following a behavior based line of thought, Studer (1969) suggests the use of "behavior" for operationally defining "need", so that consequently, developmental needs could be expressed in terms of developmental behavior patterns. Yet "behavior" is also a psychological term which does not clarify or directly relate to environmental conditions. That behavior is affected by the built environment is readily accepted in all research, yet, we have to be conscious of the fact that our knowledge of behavior is arrived at by the identification and categorization of observed activites and interpersonal exchanges. Behavior is an important information source, but its occurence has to be ultimately related to the physical environment in which it occurs, so that a knowledge of behavior alone is not sufficient for evolving design concepts. We suggest that instead of attempting to relate "behavior" to the built environment, our unit of analysis should be "activities", since they represent the most directly quantifiable and qualifiable relationships between the child and the built environment. Also, in most environmental investigations, the use of the term "behavior" is interchangeable with that of "activity". For example Canter (1970) states that "...in the great majority of cases behaviour and the places in which it is carried out seem appropriate to one another. It is generally accepted that people sleep in bedrooms, sit in sitting rooms, do clerical work in offices, and so on...". We suggest that "sleep", "sit" and "do clerical work" although classified as behavior, can also be considered as activities and that the appropriateness of the environment can be related to the activities performed therein. To further clarify, activity concerns itself with "what is being done", "how is it being done", "where is it being done", and "when is it being done", while behavior extends the sphere of inquiry to question "why is it being done". Although this last question is extremely important, it's answer is not directly relevant to the design process and should be left to causal studies of behavior and environment. The design process, also concerned with what, how, where, and when, can therefore obtain a more specific clarification of environmental conditions from a statement derived from the study of activities.

That developmental needs could be identified in terms of activity patterns appears to be supported by several developmental theories:

- in Piaget's theoretical formulations, one of his main developmental themes concerns itself with the fixed nature of the order in which successive structures of behavior and thought make their appearance in the developing child (McV Hunt,1961). We can simplify by stating that all aspects of development are interrelated and evolve in predictable consecutive cycles.

- Piaget's experiments indicate that "...our adult understanding and representation of space results from extensive manipulations of objects and movements in the physical environment,..."(Hart & Moore,(In Press) namely that "...learning is dependent on the activity of the learner ..."(Brearley & Hitchfield,1970) (added italics).

- Gesell's experiments perceive development as a series of events governed by laws and forces (Gesell, 1943). These are described in terms of normative activity patterns in the description of the "behavior day" (Gesell & Ilg. 1943)

- one of the major developmental means of children, play activities, are acknowledged as being direct reflections of developmental stages and are classified according to developmental levels. The play activities of children have been investigated from the standpoints of what such activities reveal about motor development, social development and cultural development (Munn,1965).

These theories indicate that some elements in the child's development are always clearly represented by activities. Further, these theories suggest that we could represent some child development by activity development and therefore, design oriented developmental needs could be identified in terms of predictable developmental activity patterns.

Activities

Within the scope of "normal" child development, we identify three categories of activities:

1. Self-initiated activities result from the maturation of the organism. We refer to "phylogenetic" activities, ie. activities which are alike in all human infants. Such activities include the typical reflexes, crawling, creeping and walking.

2. Self-initiated directed activities are motivated by physical and social environmental conditions. We refer to "ontogenetic" activities; "...(habits which the normal infant may or may not acquire).../where/ Exercise has a considerable influence upon the development of such activities..."(Munn,1965). We presume a stimulus-response condition in which we classify these activities as the desired response or output, and the physical environment as part of the stimulus or input. For example, in nursery schools, self-initiated directed activities are a function of the available materials, of environmental conditions and of social interactions (Pollowy,1969). Also, if we observe playground activities, the available equipment as well as peer group involvement motivates certain types of activities which we classify as self-initiated directed activities. Therefore, to satisfy and stimulate design-oriented developmental needs, the relationship aimed for is the optimization of physical environmental stimulus to encourage the predictable developmental activity patterns.

3. Directed activities are performed in response to explicit directions. For example, when a child is told to paint, listen to stories, play with blocks, etc. at a given specific time, the choice of the activity and of the timing of the activity is extraneous to him.

In this paper we are mainly concerned with developing an operational framework into which self-initiated directed activities can be inscribed, since these are the most complex activities, and the most difficult to directly relate to environmental conditions. In the pre-school years, these activities occupy most of the child's time and are the most important for his development. Also, changing concepts in education consider more and more the activity of the learner to encourage learning, with the consequent fading of directed activities.

To what extent have "self-initiated directed" activities been empirically related to the built environment?

In the field of engineering, research activities were mainly concerned with programming the built environment to satisfy those aspects of behavior or activities that could be expressed as a function of comfort level variables (School Environment Research,1965). Research in psychology, physiology education and mental hygiene has concentrated until recently on the effects of built environment on behavior. They have demonstrated direct effect on early learning processes, aggressive behavior, territorial behavior, etc. (Jersild & Markey,1935; Johnson,1935; Markey,1935; Murphy,1937; Muste & Sharpe,1947; Body,1955; Munn,1965; Hutt & McGrew,1967). Only from the investigations of Hutt & McGrew (1967) can some qualified empiric data for design be derived. Their experiments relate various aspects of child behavior to well described environmental conditions. Density conditions, room sizes and shapes are described and can be correlated with activity patterns within the physical environment, thereby obtaining clear environmental cause-effect relationships.

An exploratory investigation by Pollowy (1969) was designed to study patterns generated by tactile relationships between child activity and components of the built environment. The built environment was considered as that part of the child's exterior surroundings that is in condition of acting on him or submitting to his actions (Couffignal,1953). For the study it was limited to those components to which child activity could be physically related, ie. elements such as floors, walls, toys, tables, chairs, etc.. Activity was defined as the tactile interaction between these components and the child. The investigation, carried out in three environmentally different nursery schools (with a similarity in the children's cocio-cultural group and in the educational concepts), indicated the greatest variety of activities (interactions) during "free play" periods (periods of self-initiated directed activities motivated by environmental conditions). From the generalized findings the following child-environment reactions were identified:

- the distribution and accessibility of play equipment is as important for increased variety in the activities as the total floor area available,
- the visual identification (by the child) of specific activity areas is necessary to encourage those activities,
- the types of activities as well as supervisory involvement are dependent on environmental conditions (Floor area, activity area location, furnishings distribution and density, etc.)
- the child's initiative in the choice and type of activities can be considered to be a direct factor of environmental conditions.

Based on the results of the exploratory observations, the possibility of deriving design determinants from the analysis of activity-environment relationships is the major implication of this study. The analysis succeeded in qualifying the relationship between activity and characteristics of the built environment, so that it became apparent that activities could be encouraged or discouraged according to physical characteristics of the built environment. This study empirically supports the stimulus-response/environment-activity hypothesis, and although the observations were carried out in the limited environment of a nursery school, it would seem possible to explode the experiment at geographical levels.

The Performance Concept

The performance approach has been already implemented with great success in problems concerning themselves solely with hardware delivery. It can also be applied to software problems; the very statement of the user's "wants and needs" to be satisfied by the intended physical environment.

The Performance Concept is an approach which aims at both qualitative and quantitative built environment solutions. "The concept is centered on the idea that products, devices, processes, systems or services can be described, and their performance measured in user requirement terms without regard to their physical characteristics or methods of creation." (Kushner,1969) & Wright,1970). Wright (1970) further states that "The performance approach demands a statement of performance in terms of function. Since buildings serve people, function is defined by the attributes necessary to satisfy human requirements - the means of delivering the attribute is left open. ...In the performance approach a specific building system, component or material is subservient to the delivery of an attribute. That in turn is subservient to the satisfaction of human needs."

Assuming that we know what a specific environmental problem is, we have to clarify what human problems are involved and consequently specify the required performance of the built environment that is to satisfy conditions of human performance. "Looked at in its simplest terms, a specification of performance requirements merely makes the purpose to be served or the needs to be met explicit in ways that do not unnecessarily restrict the designer's response to them." (Mainstone,Bianco & Harrison, 1969). As a matter of fact, the use of the performance approach allows designers the greatest freedom in the choice of alternative solutions, since it is only the expected performance of the built environment that is specified without indication of the means.

The scope of this paper is restricted to developing the performance approach for that statement of user requirements which can evolve from the identification of children's developmental needs.

We conclude that accepting the hypotheses that:

- developmental needs could be identified in terms of developmental activity patterns,
- self-initiated directed activities are a desired output and the physical environment acts as part of the input, and
- the analysis of activity patterns can identify design determinants

the clear statement of developmental activity patterns is the means for describing the interface between developmental needs and the designed environment. Also, considering that the performance concept concerns itself with the performance of the built environment to satisfy the "wants and needs" of the user, explicit environmental conditions required for a stated set of activities could be inscribed within an operational framework through the performance concept, thus defining and structuring the environmental problem in design terms.

THE DEVELOPMENT OF AN OPERATIONAL FRAMEWORK

The need for an operational framework

Why is an operational framework necessary to relate developmental needs to the built environment?

There are two fundamental reasons: First, the statement of developmental needs within a given social context involves several disciplines, where each discipline corresponds to a certain segment of empiric knowledge. There is a gap of communication between the various disciplines which consequently creates gaps in the overall knowledge of a problem (Boulding,1956). We have identified an immediate gap between development, behavior and the built environment which we have filled with "activity".

A well defined framework allows for the further identification of both communication and knowledge gaps which have to be filled in order for it to become truly operational. Second an operational framework is necessary if we are to establish coherence and continuity between the knowledge of developmental needs, the statement of user requirements and the final product: the built environment.

Communication-the statement of an environmental problem

If we are to produce a clear and comprehensive statement of an environmental problem, which within an operational framework lends itself to the coherence and continuity we are aiming at, we have to define who is to make that statement.

We perceive that if we are to take into consideration the developmental needs of the child, we encounter a team composed of the sponsoring user, the active user, the designer, and a group of multi-disciplinary specialists. Within this team we identify:

- the sponsoring user as the one who will define the goal of the built environment, will outline the function of the built environment, ie. the directed activities that are to be undertaken, and who will sponsor the construction program,
- the active user as the one who will use the built environment (in this case the child and the adult, who may not be represented by the sponsoring user). The built environment has to respond to their "needs and wants" (for the child, the built environment being the stimulus that will provoke a desired response through self-initiated directed activities),
- the designer considered mainly as a synthesizer for this stage, and who may or may not be a member of the implementation design team. He has to be highly familiar with the design process, and has to be able to make the required predictions at the level of the statement of the objectives, and for the identification of the performance requirements and criteria,
- the group of multi-disciplinary specialists is particularly important if we are to identify the developmental needs of the child. They are to clarify and state what these needs are to be in the given context of the environmental problem. Their task would be to analyse and relate various developmental theories such as Lewin's, Piaget's, Erikson's, Freud's, Gesell's, etc. in order to arrive at a comprehensive statement about the child's developmental needs at a given age, within a given social context. They are the specialists from whom the initial information has to be obtained in a manner to allow classification and identification according to desired activities.

The Operational Framework

"The architectural design process can be considered from the present point of view as the fitting of a physical form to a complex pattern of human objectives, activities and requirements. This necessarily involves identifying the requirements, devising the form and finally appraising the "fit"....Before the "fit" can be objectively appraised it is necessary to decompose the ultimate objective progressively into the sub-objectives and to define appropriate activities conducive to the achievement of each and the requirements that these activities generate." (Mainstone,Bianco & Harrison,1969).

The Performance Concept Tree

We consider that an operational framework should be assembled as a hierarchical structure to ensure the required continuity, starting from:

Level 1. - The statement of an overall goal which is the optimization of children's development within a given set of circumstances. This goal is basically a general statement of ultimate intent which relates to the specific social, economic and environmental conditions that prevail in the context of the problem.

Level 2. - From the goal, distinct objectives can be derived. Objectives, by definition, have to be reachable, and one's efforts are expected to attain or accomplish them. Namely, one must predict that means to achieve these objectives are available or could be developed.

Prediction is the essence for the implementation of the performance concept. This implies that the problem stating team must pool sufficient expertise to be able to predict within reliable limits that the objectives are achievable within the context of the environmental problem, in order to avoid the consequence of both over-design and under-design.

Level 3. - It is purely a matter of convenience to divide each objective into as many sub-objectives as are necessary so that a problem becomes manageable.

Prior to Level 4. (the user performance requirements), we wish to clarify what the objectives should express and in which terms they should be expressed. In the previous section, we have presented our argument for using "developmental activity patterns" as the means for describing the interface between developmental needs and the designed environment. Therefore objectives (and sub-objectives) have to be described in terms of explicitly stated sets of activities which are expected to take place in the intended environment. For each objective or sub-objective there will be one set of activities, however, similar activities could be present in various sets (ref. Set Theory). Within each set, the basic activities for that set have to identified with their paradigms. These are the inflections of the basic activity indicating its various aspects; how the activity is taking place, where the activity is taking place, how many participate in the activity, etc. In the paradigms, the procedure should be statement by exception, only the relevant inflections being identified.

The overall continuity could be illustrated by the following example:

Objective: auditory perception

One of the sub-objectives: recognition of a series of sounds

One of the identified sets of activities aimed at: experimenting with musical instruments

Basic activities in the set:

1. sit and listen
2. experiment with a specific musical instrument
3. sing

etc.

Paradigms of basic activity #1. - "sit and listen"

how:
1. sitting on the floor
2. sitting on seats
3. informal seating
4. formal seating (various orientations)

etc.

where:
1. interior
2. exterior
3. open space
4. enclosed space
5. quiet space
6. large space
7. small space

etc.

when: should indicate the frequency of occurence of the activity

how many:
1. alone
2. groups of 6
3. groups of 12

etc.

Once all the activities have been established for the various objectives, the next phase (Levels 4 & 5) can take place. This consists in relating activities to environmental conditions by developing Performance Requirements and Performance Criteria to arrive at comprehensive Performance Specifications. Through this process, characteristics the built environment should offer are identified so that the performance of the environment satisfies the conditions in which the activities are to take place.

The technique to be implemented in this process is evolved from the Performance Approach and is developed through a sequential process following a hierarchical path, the "content" produced at each step increasing in rigour. The product of this process would be the "User Requirements Performance Specifications". (Evidently, some basic user requirements will not be directly related to specific activities, and should be expressed as general requirements; eg. health, safety). In order to avoid redundancy and contradiction in the statements of User Requirements Performance Specifications, only the very elements that are essential to meet the objectives and sub-objectives should be stated. For the various requirements indicated, their relative hierarchical value or weight (according to evaluated importance) should be indicated in order to allow the designer a range of options in the choice of criteria during the design process. Also, the performance requirements shall only be concerned with "what is the problem" and "what shall be achieved", and in no way should they include a loaded statement which implies or indicates a means to achieve the ends.

Level 4. - Performance Requirements are the quantified and/or qualified product (characteristics of the built environment) resulting from the analysis of the user's activities. Comprehensive narrations stating which conditions are required to satisfy the various levels of activities the user will be involved in. According to Wright (1970), "A Performance Requirement is a qualitative statement describing a problem for which a solution is sought. Ordinarily, a Performance Requirement will include identification of: what the nature of the problem is, who has the problem, why the problem exists, where the problem exists, when the problem exists."

Level 5. - Performance Criteria-Once the Performance Requirements have been stated, it becomes necessary to establish reference principles which will allow for the evaluation of the proposed solutions. The key to the dedevelopment of Performance Specification is the identification of significant criteria which characterize the environmental performance expected. The purpose at this level is to isolate, identify and select measurable properties or characteristics for each Performance Requirement. Also, to subsequently single out relevant performance evaluation techniques, or, if these are not available, to develop new evaluation methods. (There are testing methods available to evaluate certain physical characteristics of the environment, eg. acoustical testing, lighting testing. Other evaluative techniques such as scoring methods, could be applied to evaluate the actual concept or weight alternate solutions) It shall be noted that,when the nature of the criterion (or of a set of criteria) does not allow either for scientific judgement methods (eg. test and measurement), or empiric judgement methods (eg. simulation techniques-when the criteria are not amenable to quantitative measurement), it is accepted to recourse to expert judgement.

Note: When the state of the art, or the nature of the problem, does not allow for quantifiable principles of judgement, performance criteria are replaced by "performance requirement guidelines", relying on expertise evaluative techniques for final judgement.

The procedure used for channelling the information of Levels 4 & 5 to the party or parties the solution is sought from consists of the documentation of the Performance Requirements and Performance Criteria in a format referred to as "User Requirements Performance Specifications". This comprehends in its final form all information and data relevant to three types of statements:

1. The statement of the problem (performance requirements)

2. The acceptable levels of performance (performance criteria) the solution is to meet

3. The evaluative techniques to be implemented.

The User Requirements Performance Specifications (Performance Requirements and Performance Criteria) will identify all the environmental parameters relevant to all described activities. These parameters are to be specifically categorized into families of environmental conditions such as spatial requirements, spatial delimitations, perception of the environment, acoustical condition, physiological condition (illumination, atmospheric control), etc.

Level 6. - It is at this point on the Performance Concept Tree that the designer takes over. He has received the "User Requirements Performance Specifications" as part of his program, and the design process is initiated. The designer analyses the function the built environment should perform in relationship to built attributes that perform these functions, and identifies those design factors he will respect in order to meet the User Requirements Performance Specifications. The designer determines these design factors through the analysis of:

- the User Requirements Performance Specifications

- the contextual constraints (economic,climatic,code regulations,etc.)

- the state of the art (technology) and the available resources

- the design variables

He will then conceive a solution and determine the optimum characteristics of the built environment attributes. Delivery of these attributes is achievable either through the traditional descriptive path or through the performance approach.

Feedback

In addition to the fact that feedback is necessary to any operational framework, it is absolutely essential when the user and the built environment are approached as a whole. The available holistic methods of evaluation are based on empiric techniques (simulation) that can lead in most cases only to posterior evaluations whose results are available during the operational stages of the built environment. Regarding empiric methods of evaluation, their perfecting has to be considered as a dynamic process which undergoes constant re-evaluation in function of feedback findings.

Within the described operational framework, we perceive of feedback at four levels:

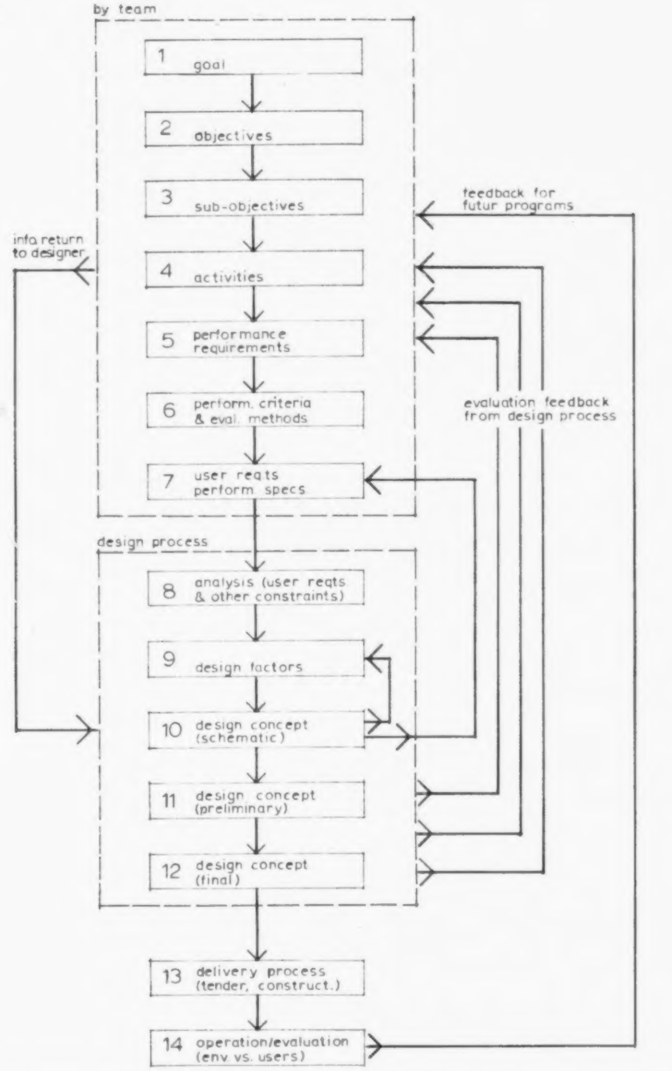
1. In the development of a solution, the designer at all times refers to the User Requirements Performance Specifications as a means of evaluating his choices of attributes.

2. The evaluation of the complete solution can refer to the whole of the User Requirements Performance Specifications and to the Program, to verify if the designer has fulfilled his mandate.

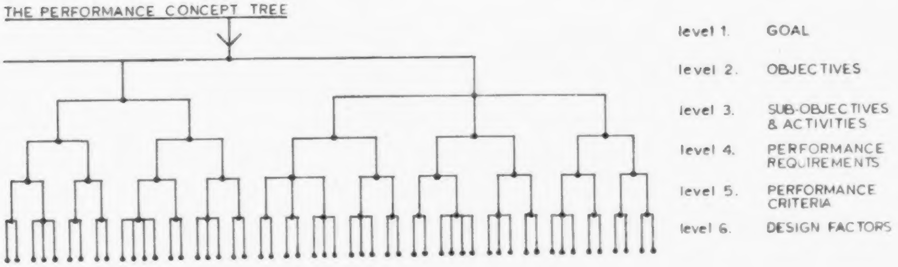
3. Feedback from the closed cycle, where posterior evaluations are made from the built environment designed and implemented throught the complete performance approach. This provides feedback on the environment as well as on the process itself.

4. From the evaluation of any built environment, new empiric data on activity-environment relationships can be incorporated into existing User Requirements Performance Specifications, hence becoming immediately applicable to new environmental problems.

PROCEDURE FLOW DIAGRAM


by team
1 goal
2 objectives
3 sub-objectives
4 activities
5 performance requirements
6 perform. criteria & eval. methods
7 user reqts perform specs
design process
8 analysis (user reqts & other constraints)
9 design factors
10 design concept (schematic)
11 design concept (preliminary)
12 design concept (final)
13 delivery process (tender, construct.)
14 operation/evaluation (env vs. users)
info return to designer
feedback for futur programs
evaluation feedback from design process

THE PERFORMANCE CONCEPT TREE


level 1. GOAL
level 2. OBJECTIVES
level 3. SUB-OBJECTIVES & ACTIVITIES
level 4. PERFORMANCE REQUIREMENTS
level 5. PERFORMANCE CRITERIA
level 6. DESIGN FACTORS

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10: MACRO-ENVIRONMENTS

EVALUATION AND REDESIGN OF COMPLEX MAN-ENVIRONMENT SYSTEMS

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Man's usual interest in man-environment systems is to improve system outputs by redesigning some inefficient system interaction. Are there too many highway accidents? Modify the geometry of conflict points on the highway in question. Is too much time spent in coffee breaks? Decrease the intensity of interpersonal interaction. Do the underemployed exhibit a modally short job tenure? Retrain them. Is a weapons system ineffective? Replace it.

A large part of current scientific and engineering literature can be interpreted as being organized around the evaluate-and-redesign theme. For example, in our study of a cross section of man-in-built environments literature, we found that most of it followed this pattern. Whether the study was an investigation of how students study best, what office environments produce best results, or for whom such institutions as hospitals are really operated, the purpose could be interpreted as evaluate-and-redesign. Applying this concept to the weapons systems studies of Navy scientific and engineering facilities, we found that they, too, followed the pattern. So did the various studies of the automobile transportation system.

However, most man-environment systems are so inordinately complex that evaluation-and-redesign studies tend to be partial at best. The highway engineer considers highway geometry, road markings, signing, lighting, etc. The psychologist investigates driver reaction and training. The automotive engineer is almost exclusively interested in the nature of the vehicle as an independent system. The legislator designs new laws, prompted often by the latest and most publicized system failures. Police are then forced to design new enforcement methods.

Almost inevitably, the consensus is that the central problem is the driver. Ours is a culture in which culpability must be assigned, and in the automobile transportation system it is easiest to blame the driver--not the manifold and essentially anonymous individuals who design the artifacts of the system, nor the equally anonymous makers of laws. There is a beginning awareness that our man-environment systems place too great a burden on mere man, despite his adaptability and trainability. No-fault insurance is one indication of this awareness. And inevitably it will be commonly accepted that in automobile transportation systems such faulty outputs as traffic tie-ups and accidents and inordinate trip times are almost inevitably the product of system design.

The basic reason that designers do not yet think in total systems terms is that man-environment systems are terribly complex. Actually, most of them exhibit the degree of complexity which elicits the human reaction, "I can't hope to understand that!" But it is in terms of the conventional approaches to analysis that the complexity is enormous. The individual scientist or engineer, unaided, cannot hope to comprehend the nature of most systems; and it is a fact that most scientists and engineers do work alone, or with others of like training. Few have at their command the enormous amounts of data required simply to describe complex systems, let alone make generalizations about them.

Another reason for the general failure to think in overall systems terms is that most scientists and engineers and designers are trained to understand or investigate only one or another aspect of a total system. Urban planners design broad areas of land use. Landscape designers lay out neighborhoods. Architects design individual houses. Interior designers create house decor. The designer operates within the constraints of the encompassing design. But seldom is he capable of understanding the relationship of his design to all other related designs in terms of their capacity for supporting the human activities they must support.

The foregoing is not meant as a criticism of the designer, but only to specify an urgent need. Somehow each designer must be given the opportunity to see his efforts in a larger perspective than his limited sensory and analytical capabilities afford him. To comprehend man-environment systems in anything approaching totality one must organize vast amounts of data by means of comprehensive and logical models, and this means, among other things, that one must use computers as extensions of man's limited capacity to store and retrieve complex data.

In our investigation of the Navy laboratories' evaluation-and-redesign studies of naval weapons systems and components, we found that of 300 studies no two were precisely alike. We developed a system of notations to describe the nature of each study, in fact, and found that the notations represented a wide gamut of patterns of interaction variables. To attempt to synthesize generalizations from 300 different complex equations visually is not wise, nor is it wise to generalize from 300 cases when the universe of documented cases is far larger than that. But the computer has the capability of total, errorless recall for numbers of different or similar cases far in excess of the number of reports available, and it can compare and sort in rigidly logical fashion, guiding one to generalizations which can lead to hypotheses which can lead to the statement of principles.

In other words, we believe that data now available can be integrated, via models and information systems, into concepts describing the structures of man-environment systems in such a way as to begin to relate system design to system outputs.

We have been led to this conclusion through our experiences with three different studies. One has been a continuing effort to design for the Navy a "coastal" information system such that the relevant data about coastal environments would somehow be related to the requirements of naval operations in such environments in a useful manner: Phases I and II of that study dealt with structures and requirements, leading us to the inevitable conclusion that we could not create an information system without knowing something definite about the nature of the Navy ecosystem, which was defined in Phase III. Another study, again for the Navy, was an investigation of naval artifact environments as they influence the behavior of personnel carrying on activities in these environments, and this led us to an attempt to generalize principles of man-environment relationships, which we could only do by defining the terms used to describe such principles. The last study was a somewhat superficial analysis of the automobile transportation system as it relates to psychological aspects of driver training; it was a paper written for a NATO conference; in effect, we attempted to apply what we felt we had learned in the preceding projects.

Coastal information system study (Phases I and II). The attempt to design an information system describing coastal environments (1) was based on the assumption that the quality of naval activities will reflect the relationships of these activities to the varying environments in which they take place. More directly stated, every weapons system -- and in fact most military materiel -- is designed to operate within some specified environmental parameters. The general notion here is that there is some kind of "impact" of the setting upon the operation of the material used in the activity. So long as we followed this general idea, we got nowhere. The ways of describing physical setting are infinite and seldom can they be demonstrated to bear specific kinds of relationships to the operation of specific materiel. To give a simple example, we know that the effects of *fog* are really contingent upon the entire nature of the activity. One effect of fog is to reduce visibility -- e.g., on a landing strip. However certain kinds of fog can be prevented by us of induced winds and turbulence. Certain kinds can be dissipated with chemical sprays. Guidance systems for planes greatly alter the impact of different degrees of fog upon the landing operation. Under most circumstances, planes can be rerouted to other destinations. A carrier can move to fog-free areas. Eventually, but only after we had begun to study the effects of built environments on man, we realized that weapons systems operations had to be considered in terms of total man-environment systems.

Naval base study. The literature which had bearing on our naval base study (2) was so various that we were immediately challenged to devise schemes to simplify and organize it. Because the focus of our concern in this study was man -- i.e., human behavior -- we expressed our organizing scheme as an interaction between man and his various environments. We assumed that the *natural* and *human* environments were given and that the intervening environments of *artifacts* and *concepts* were constructed by man. Man we identified as being subject to the impact of nature and other men, as the creator of the intervening environments which modified these impacts, and as being subject to the impact of the created environments. The definition was anthropocentric and classificatory. The principles of environmental design, as we elucidated them, had very definitely an environment-affects-man and man-judges (or perceives and judges)--environment tone.

Naval ecosystem study (Phase III of coastal information system). We attempted to specify the nature of the complex ecosystem called Navy, basing our description empirically on investigations made by naval laboratories and other scientific and engineering activities (3). We adopted the terminology used in the naval base study but found that it had to be modified and directed away from the man-environment dichotomy. That is to say, we found that we had to consider man a variable in a system which was on an equal level with the other variables. With this kind of logic, our so-called "human environment" no longer constituted an independent variable. Instead, the variables of the system were identified as elements of the *man*, *nature*, *artifacts*, and *symbol* sets. With this simple classification of variables, we attempted to design a notation system which would adequately describe the findings of any study. This led to the design of a mathematical model and to the specification of a fifth variable, *relationships*.

In determining a mathematical model which could be used as the foundation of an information system we needed a model which would represent the same piece of information in the same manner even though the basic system models used by researchers might be different. A system model is a conceptual description of a situation. In defining a system model, one will usually define:

a. The internal element set - the elements interior to the system.
b. The input elements set - the elements which enter the system across the boundary.
c. The output elements set - the elements which leave the system across the boundary.
d. The environmental elements set - the elements external to the system.
e. Relationships which exist between and among these elements.

As different people develop different models for the same situation, the definitions of the sets described in a, b, c, and d above change. Our attempt is to define a model for the variables and the relations determined in a system study so that this set distinction may either be ignored or retained depending on how important the model is to the piece of literature being coded at the time.

For a particular system model, let

I = interior elements of the system

J = input elements of the system

O = output elements of the system

and

$\mathcal{E}$ = environment elements of the system.

Then the set

$$V = I \cup J \cup O \cup \mathcal{E}$$

represent the set of all elements considered in the system model. In addition, let us define

$A = \{x \mid x \text{ is an artifact}\}$
$M = \{x \mid x \text{ is a man}\}$
$N = \{x \mid x \text{ is a factor in the natural environment}\}$
$S = \{x \mid x \text{ is a symbolic}\}$.

Based on the definitions, let the set

$$E = A \cup M \cup N \cup S,$$

then by our previous discussion on man-environment systems we have

$$V \subset E .$$

Let P be the set of all possible subsets of E. This is the set of all possible combinations of variables from the total environment. In particular we are interested in the set P_V, the set of all subsets of V. Call P_V the set of all primary system states. Finally, a relation is defined as a triplet (B, P_V, g) where $B \subset P_V$ and $g \subset B \times P_V$. Let

$$R = \{(B, P_V, g) \mid B \subset P_V \text{ and } g \subset B \times P_V\}$$

denote the set of all relations on P_V.

Consider the interpretation of this model in terms of man-environment systems. Suppose that

$$y = \{x_1, x_2, \ldots, x_n\} \epsilon P$$

where

$$x_i \epsilon V.$$

Then y may be interpreted as a combination of factors from the sets A, M, N, and S which occur together to give a combination of variables being studied. The domain of a relation $r = (B, P_V, g)$ is the set B. This indicates that every system state in B bears the relation r to one or more other primary system states. Thus, if $y \epsilon B$, then the set $\{z \mid (y,z) \epsilon g\}$ defines all primary system states which bear the relation r to y.

As an example, suppose we have the following piece of information: "In specified ways, sea water and microorganisms corrode buoys."

In this example, our variables have the following definitions:

x_1 = sea water ϵ N

x_2 = microorganism ϵ N

x_3 = buoy ϵ A

y = corroded buoy

and

r = corrosion.

Thus we could write that

$$\{\text{sea water, microorganisms, buoy}\} \xrightarrow{\text{corrosion}} \{\text{corroded buoy}\}$$

or

$$\{x_1, x_2, x_3\} \xrightarrow{r} \{y\}$$

where "$\xrightarrow{r}$" means "bear relation r to."

Note that in expressing this phrase in our model we do not have the same system states on each side of the relation, nor are the system states complete. Only the important factors in the study are represented as parts of systems states.

Many of the studies used as data for this model constitute situations which treat the relations in R as part of systems states. This is particularly true when we consider evaluation or redesign type of studies. In effect, in these studies people are considering the relations in the system being redesigned as inputs into another system, the evaluation or redesign system. These do not apply to the relations themselves but to specific elements, or sets of elements, from the graph of the relation. Therefore we let

$$G = \{(x,y) | (B, P_V, g) \varepsilon R \text{ and } (x,y) \varepsilon g\} .$$

Then mathematically we let

$$\varepsilon_V = V \cup G$$

$$\mathcal{S} = \{B | B \text{ is a subset of } \varepsilon\}$$

and

$$\phi = \{(B, \mathcal{S}, g) | B \subset \mathcal{S} \text{ and } g \subset B \times \mathcal{S}\}.$$

The set ϕ is the set of all relationships between system states in the man-environment system we are considering. An example of this would be our interpretation of the following statement:

> *Because aircraft vibration damaged battery cell walls, a new anchoring element was designed to reduce or negate battery damage.*

Expressed in terms of our model, this would be

$$(x_1 \xrightarrow{r_1} x_2) \xrightarrow{r_2} x_3$$

where

x_1 = battery

x_2 = battery with damaged cell wall

x_3 = new battery hanger to reduce or negate battery damage

r_1 = aircraft vibration

and

r_2 = design to reduce damage due to vibration.

The mathematical model described above provides the logic for an information system which is more than a data storage-and-retrieval device. Our classification system specifies that a system state is made up of members of some or all of the following sets, the nature set, the artifact set, the symbols set, and the set of all relations between combinations of elements of these sets. We can, therefore, represent a system state by a set of words or phrases

$$x = \{x_1, x_2, \ldots, x_n\}$$

and a relation by a word or phrase

$$r.$$

An entry into the information system will then take the form

$$\{x_1, x_2, x_3, \ldots, x_n\} \; r \; \{y_1, y_2, \ldots, y_n\}$$

or, more briefly

$$x \quad r \quad y$$

and the elements

$$x_i,\ i = 1,\ \ldots,\ n,\ y_i,\ i = 1,\ \ldots,\ n, \text{ and } r$$

will be part of the list of key words and phrases. This set of words and phrases will be dictated by the data being put into the system.

The kinds of data available in the literature as inputs to an information system are usually of the form

$$x \quad r \quad y\ .$$

Each such data input will not tell one everything there is to know about that particular relationship (r). Each piece of information (each data input) provides one or more points from the graph g of r. To comprehend the relationship fully, we must know g. If we can accumulate enough information about a relationship, we can either *determine* g or develop more detailed models which will provide hypotheses about g which we can then test.

Automobile transportation system study. We attempted to apply these ideas of a model of the automobile transportation system (4). We specified the variables in the system as being the following: drivers (M set), vehicles (A set), roads and highways (A set), offroad environment (A set), natural environment (N set), highway artifacts (A set), laws and enforcement (S set), and traffic (R set). Our admittedly sketchy analysis of each of these variables led inevitably to the conclusion that redesign of one element of the system without regard for its interactions with all other elements of the system provided no guarantee of improved system outputs, and we suggested application of our model to the development of an information system which would usefully, and synergistically, integrate the vast amount of scientific and engineering research published on each set of variables. This would lead to the development of hypotheses about system design as it related to system outputs and eventually to useful design models.

Conclusions. We conclude from these studies, which involved sampling and organizing and analyzing relevant literature, that the present literature constitutes a valuable source of partial, largely single-variable analyses of man-environment systems. We suggest that our definition of variables and our model may be useful concepts in creating a man-environment systems information system which can lead to useful concepts of total system operation -- and therefore to improved system design and redesign.

In effect we are saying that to comprehend large, complex systems of this sort one needs to utilize large amounts of complex information. Will any patterns emerge from larger bodies of data? We believe they will. Man-environment systems of whatever nature support some kinds of human activities which can be described and which bear some comprehensible relationship to their ambiences. We believe that for any system analysis the possible number of system states is enormous but the probable number of system states is manageable. Human activities are complex, but not infinitely complex. At the level at which we have begun to look at them we have not been able to grasp the nature of many of the complexities, so all of our statements tend to be relatively abstract. However, if our models are abstract, they are also logically rigorous, and empirically-derived, and therefore they provide, we believe, a sound basis for more and more specific and useful investigation.

EVALUATION AND REDESIGN OF COMPLEX MAN-ENVIRONMENT SYSTEMS

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CHANDIGARH: AFTER 20 YEARS

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In 1947, after two hundred years of British rule, India was partitioned and a new country, Pakistan, was created. The province of Punjab in the British India, was partitioned as well, and Lahore - the capital of the Punjab - remained in Pakistan. The Indian state of Punjab was thus left without a capital city. Many other cities in the state - Amritsar, Jullundhar, Ludhiana, Ambala, Simla - though large urban centres vibrant with life, were deemed unsuitable - for one reason or the other - to be the capital of a proud and independent state of Punjab. The idea for the creation of a new city was thus conceived, and Chandigarh - the abode for the goddess of power, "Chandi" - became the new capital of the Punjab.

The decision for the creation of Chandigarh was also a symbolic and monumental gesture, as "the first large expression of our creative genius flowering on our newly earned freedom" (Nehru), and was taken in a mood of romantic grandiosity, so characteristic of the Punjabies.

In 1950, a team of designers, comprising French architects Le Corbusier and Pierre Jeanneret and British architects Maxwell Fry and Jane Drew, was invited to design the city. Corbusier designed the Master Plan and a set of buildings - the Capitol Complex - to serve the principal functions of the state government. Other members of his team designed the residential and shopping areas, schools, colleges and libraries, government housing and other office buildings.

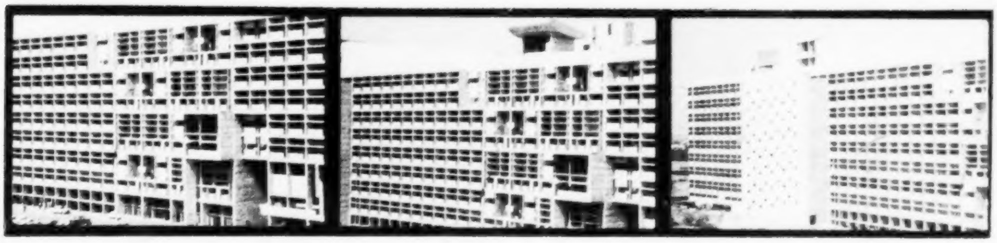
Chandigarh - "an expression of the nation's faith in the future" - was officially declared open on October 7th, 1953. Two decades after her inception, Chandigarh - in spite of many initial misgivings - has matured into an 'elite city' of over 200,000 people. As the billboards declare: "You are a very privileged person, a citizen of Chandigarh, the most beautiful city in India..."

'Most beautiful', perhaps, but with conspicuously "unIndian" architecture - Chandigarh is certainly the most unique city in India.

In a socially and climatically complex environment as exists in Punjab such a large scale experiment in urban design has attracted worldwide attention. The comments range from Paul Rudolph's "As time goes on I am sure that every man will understand the importance of Chandigarh: People will go there as they go now to the Piazza San Marco. They will go not because of any individual building but because of the relationship of buildings to the site, the environment created, the aspirations of man realized...undoubtedly the century's greatest"(1), to "a monumental city without much to celebrate", "a city designed by Europeans for unfortunate Hindus"(2).

To many critics it seemed rather incongruous that in planning Chandigarh as her "first large expression of our creative genius", an independent India should have invited a team of French and British architects. In a similar vein, Italian film director, Roberto Rossellini, in 1957 and the Canadian photographer, Rolf Beny in 1967 were invited to create their impressions of India on a film and in a book respectively to celebrate India's first and second decade of independence.

Perhaps, as has been suggested, "India understands idea men and treats them well - possibly better than any other country"(3), and thus in inviting Corbusier, the founders of Chandigarh dared to seek the best and the most imaginative anywhere. For although, unfamiliar with India's rapidly-changing social structure that was no less allusive to the English-trained Indian architects, Corbusier designed with the primal instinct of an artist, and sought to create in Chandigarh a new idiom of architecture, without any specific national connotation. "No idea belonging to folklore or the history of art", said Corbusier, "can be taken into consideration in such an enterprise"(4). "Corporate architecture" so much in vogue today, was neither his style nor his forté. By giving Corbusier an unprecedented "freedom to create his own architecture,his own methods of construction and his own aesthetic," so long as he adhered "to the requirements of the program and observed an absolute respect for the price, to the last rupee!"(5), the founders of Chandigarh, Thaper and Varma, imagined a unified, single majestic vision for the city - rather than a democratic compromise - to embody their hopes



The Secretariat, designed by Corbusier

for the new government.

To estimate the "success" of Chandigarh, as a "living city", after two decades of its inception, it will undoubtedly be futile to talk about the 'architectural quality' of individual buildings in the city. As the capital, Chandigarh has an 'official' aura about her. But offices don't make a community.

In India, the village-well, or the corner 'paan' and cigarette shop or the evening 'aarti' at the temple become the focal points for a community. In a town, a sense of community develops in residential areas, in market places, in schools, in parks, in temples and in 'gurudwaras'.

The 'life' in Chandigarh, therefore needs to be assessed in that general frame of reference.

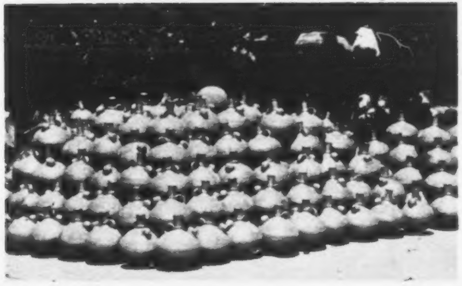
Corbusier found the program for housing and for institutional elements of Chandigarh "banal and unimaginative". He also felt that "...nowhere yet have the fundamental problems of town planning been discussed - the problems of economy, sociology and ethics, the conquest of which will make man the master of his civilization"(6). Perhaps, to study the building program at Chandigarh and its ultimate influence on the life in the city, it is important to have some understanding on the bureaucratic structure in India.

Chandigarh being the capital city has a large number of government employees, each one of whom is assigned to a subsidized housing unit, for which he pays in rent ten percent of his salary. Inherited from the British, the government bureaucracy in India, was, and unfortunately, continues to be, very "status-conscious" and derisive. A government job - at any level - was, and is, a "prize-possession", and most of the communications between various hierarchical levels in the government are no more than minimal and purely "official". This new "caste system" has reflected itself most rigorously in thirteen categories of government housing, each corresponding to a certain level of employment. The plot sizes range from 125 to 5,000 square years, a ratio of 1:40. "This large ratio appears a little "unsocialistic" in the 70's, but this was a staggering improvement over an earlier ratio of 1:1000 in 1950 when Chandigarh was conceived"(7). It is apparent therefore, that although not attempting any radical social changes, the 'program-makers' of Chandigarh did achieve some success at ameliorating the wide disparity between the upper and lower echelons of society. "We weren't out to cause a revolution, but we tried to take down the top a little and raise the bottom a little"(8).

Although Chandigarh was never intended by her founders to be a social experiment, "every attempt was made to see as far as possible that the city does not get divided into water-tight compartments of various classes of society"(9). Unfortunately, however, many feel this is precisely what has happened in the city: the houses in each category are self-consciously clustered together, making them quite aloof from those in another category, thus creating, what some consider, socio-economic ghettos.

In Chandigarh, the external differences in house styles and their distinct numbering, make the "status and wealth" of each resident immediately obvious. It was perhaps hoped that by keeping different categories of housing apart, this inevitable disparity would not constantly loom large over the minds of the residents. And since the planners at Chandigarh "were not out to cause a revolution", they perpetuated, only if a little more scientifically, a system that they thought has prevailed for so long in rural and urban centres in India and elsewhere.

Maxwell Fry, who had had extensive experience of town-planning in West Africa, is quoted to believe that "...it never pays to mix highly contrasting economic groups - the very high and the very low - the lord and the stable



An 'unplanned' street corner

'Jain' priest

Sikh 'gurudwara'

boy", that "one can mix only within a fairly narrow socio-economic range"(7). From purely physical considerations as well, it was regarded "unaesthetic" to design a set of entirely divergent sizes of houses next to each other. "They - the designers - insisted on a certain urbanity, certain disciplines of forms ...thus they created enclaves, of low and high density, for different groups of employees"(7).

Among the lower income groups and the clerks, "the majority of the people expressed strongly against the 'Categorization' of the houses. They do not like it as it creates discrimination between the residents in the houses of different types ... Many respondents suggested a lesser number of types"(10).

Considering the socio-political climate at the time of Chandigarh's inception, a great many considerations in design and layout of houses in the city are ingeneous and perhaps it is only the 'over-zealous socialists' who feel perturbed by these classifications.

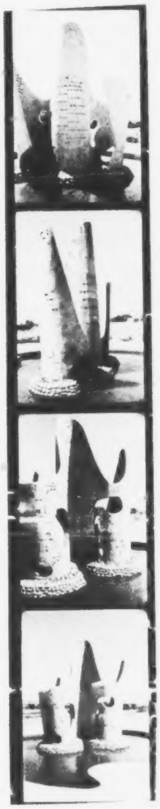
In the 1950's, in most of the Indian homes and neighbourhoods, the sheer lack of basic physical amenities - ventilation, water, electricity, parks - was so preponderant that in designing the new city, considerations of deeper "spiritual values" - whatever their architectural implications - could be easily obliterated.

Maxwell Fry expressed that "...a good deal of planning is entirely conjectural, but where architecture is concerned the process of creation takes the present facts as they stand - the "needs" of the people, the materials, and structures available, the economics as they exist ... and transforms them by an act of the imagination into a new thing"(11).

Thus the team of French and British designers, so overwhelmed with the details of construction, budget and climatic considerations, let themselves be preoccupied with seeking solutions, primarily to the most pressing 'physical'

Cinema in Sector 22

A private junior school



Sculpture

A kindergarten

Hair-cut on the road

problems, of which there were many.

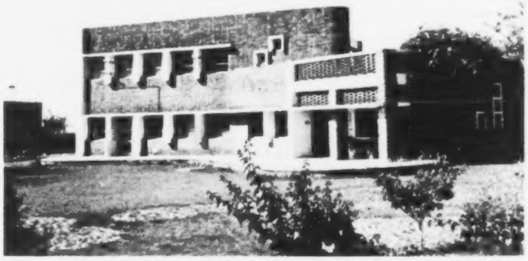
In the development of the second phase of Chandigarh, since 1968, both the number of house categories and their mutual relationship has been 'radically' revised. Specifically on the semi-educational-industrial campus of the Central Scientific Instrument Organization (C.S.I.O.), the categories of housing has been reduced to six. By using the same construction materials and architectural idiom, and by mixing a much wider range of socio-economic groups, a more unified village-concept has emerged.

Different categories of houses

However, it is important to understand this 'categorization' in a certain historical perspective. Until very recently - and some feel even now - the traditional Indian society has been most intricately structured into castes, sects, villages, religious and language groups, and to top it all, a ruling elite, nurtured by the British. Mutual economic dependence did bring these divergent groups together in some physical proximity - mostly rural - but much of the social interaction that prevailed reflected a similar kind of symbiotic relationship. The existence of economic and social disparities - and they were numerous - were accepted often with a fatalistic attitude, as part of a 'cosmic order', much beyond the comprehension or control of any mortal being. The members of such a tribal-unit, inhabited essentially a universe beyond 'free will'. Devoid of "unions" or "rights", this universe had, undoubtedly, occasional moments of great compassion, but was eminently convenient, in Marxist analysis, for exploitation.

Under such circumstances, the 'family' became the core for much of the social interaction. But a 'family' was by no means small, since traditionally three or more generations often lived together in the same dwelling. In a "joint" family, such as this, ideally, there are no "personal" belongings, or "private" space - everything belongs to everyone. It is truly a socialist system that has "worked" - with some trepidation - for over 3,000 years, in an environment that has been essentially rural - over 80 percent of the population in India still lives in the villages. Because of this "joint" use, a distinct delineation for different spaces in the house - except for the kitchen and the lavatory - has never been quite established. Even in upper class homes, the whole gamut of drawing, dining, bed and guest-room, etc. are totally new concepts, and are undoubtedly, an alien influence.

In Chandigarh, eighty percent of the government housing has been constructed for lower-income groups, a large percentage of whom had very little experience of urban life. The minimum accommodation provided in a "one-family" government house was two rooms, a kitchen, a water-closet, a bathroom and a courtyard - built at a cost of $410. The first design for this minimal house was done by Jane Drew, who grouped these single-storey terrace houses in a village-like cluster. These houses, although cramped in size, represented an enormous improvement in living conditions for many of their inhabitants who never before had occupied more than one room or enjoyed running water or electricity in their homes.



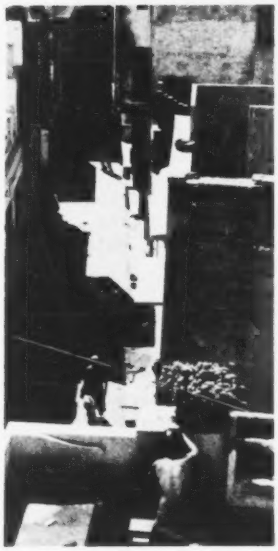
Over the past two decades or so, there has been a large migration from the rural to the urban centres. With a gradual industrialization, there has also been an enormous proliferation of new professions - in transport, construction, marketing, industry. With the result, the structure of the "joint" family - particularly in the city - is beginning to alter.

However, since the "one-family" unit, especially in the lower class of civil servants, still means a "joint" family, these two-small room dwellings are being inhabited seldom by fewer than eight members. In some cases, part of the house has been surreptiously rented out, to meet with ever-rising prices for food, clothes, and house rentals. The congestion in these houses is thus apparent, and often has resulted in slum-like conditions.

Since a new city - or a new home - does not imply higher wages, the maintenance of these quarters is often poor, and their abuse seems inevitable. There is also a development of regular "slums" on the periphery of Chandigarh. These slums are inhabited mostly by the menial labour and construction workers, who couldn't - and in a few cases, didn't want to - afford anything more permanent than the huts which they have built on vacant land within the city. "When we began to move about we realized that there were vast masses of people who were not included in the project estimate, and we tried to make provisions for them, but in a certain sense we failed. There was no economy upon which we could do it, even with the smallest houses"(12).

At present these slums are unfortunately, a more or less permanent fixture in the city. And the problem of their removal has taken intricate political overtones.

Haphazard growth in old town



It may be pointed out that traditionally most of the people in India - both poor and not-so-poor - have given very little consideration to the interior of their homes - either in terms of decoration, or use of space. Traditional Indian homes are closed-in castle-like structures, that serve, for the most part, as a protection against the vagaries of nature, the menace of the burglars and for the privacy of the women. The housing at Chandigarh - with its low and thin walls, frail doors, strange sun-breakers - seemed to defeat all the traditional purposes of a house. In a survey in 1957, 49.2 percent tenants in government housing complained of lack of safety. objecting to windows and ventilators without iron bars or wire gauze (13). However, "76 percent preferred their Chandigarh houses, to their former residences in other towns, for such amenities as shower, baths, convenient water taps, water-closets, courtyards and general good planning" (14).

With "existing encumbrances of old towns and old traditions", it seemed apparent the new city would have to create a new idiom of architecture, that must, of necessity, be alien to the people. With rapid and often unforeseeable changes in Indian family-structure and social morés, the challenge of creating a long-term architectural frame-work was horrendous. Jane Drew, one of the members of the team at Chandigarh, refers to this challenge: "The clerk's houses ... originally, were built to a plan which strictly followed the established customs and taboos, and later to a more modern form which had less passage-way and where sweepers would cross the living room, and where balconies had no purdah verandahs. It became clear very early that tradition was not important except where it followed the climate and habits of living. All modern innovations such as high level stoves, room opening off each other and so on were welcomed" (15).

In the Punjab, traditionally, the number of cattle - cows and buffaloes - a family owns is a matter of status in the society. The courtyards in a house are used for the cattle. An open verandah with a roof - an extension of the living quarters - provides protection for the cattle during winter. In India, where agriculture has been the basis of the economy, such characteristic closeness between cattle and humans is entirely inevitable. However, in an urban centre especially in a new capital city such as Chandigarh - such "closeness", it was argued, would hamper many significant civic patterns of life. The planners at Chandigarh - much against the protests of her earlier settlers - outlawed all cattle within the city limits, thus creating a unique city in India. Such an act, though eminently sensible and logical, alienated many people, especially in high places, some even in the cabinet of the Punjab government. "A superintendent's wife objected to a house design because it didn't provide a wall surface on which cow dung cakes could be plastered. When informed that in Chandigarh she would not be allowed to keep a cow by her house, she was outraged. What was the point of becoming a superintendent if you could not have the prestige of keeping a cow?"(16)

Generally speaking, in spite of its variance with many traditional patterns, the government housing of Chandigarh is considered satisfactory by its occupants.

Mulk Raj Anand, one of the foremost writers in India, sums up the social influence of Chandigarh-architecture thus:

"Le Corbusier has indeed carried out the bourgeois revolution in Indian architecture, by enabling the middle and lower classes to expand themselves into the four to five-roomed life. And if he could not get over the class system, and divided the rich from the poor, all the same he released a social revolution in the lives of the poor by giving them verandahs, smokeless kitchens, flush lavatories, front gardens and the urges to demand a classless and casteless society ... It is true that Corbusier and his associates didn't give the Punjabies the open verandahs they love, perhaps because he saw them in English striped pyjama suits and not in tunics and helmets, nevertheless...this town of the future seems like a miracle, wrung out of the heritage of indifference and bad taste left by the Victorian British minds who ruled us for two centuries"(17).

At present, socially there is much to be desired in Chandigarh, but the extent to which this can be attributed to planning is problematic. Cities are "impersonal" and "alienating" anywhere. In Chandigarh, a great many residents have migrated from either rural areas or a 'cosy' atmosphere of a small-town. As is inevitable, there is a sense of 'uprootedness' - characteristic of all new areas. However the most debilitating factor in the growth of Chandigarh as a warm, human community is that Chandigarh is a capital of an out-moded government bureacracy, which generates an arid atmosphere of 'officialdom' that suffocatingly permeates the city.

One student-survey showed that amongst an upper middle class area, "the allotment of houses on the basis of income and occupation creates a sense of superiority among the government servants and their wives and children. Consequently higher officers and their wives find it below their dignity to visit a neighbor who is subordinate to them in occupational status"(18).

A survey amongst white-collar workers in another area concluded that "the habit of extending invitations among the residents is in a very low ebb. If at all there are any invitations, they are only on formal occasions which are celebrated under social compulsion. Very few invite their neighbors for tea or dinner... People seem to lack confidence in one another... So it may be said that the neighborhood relations in the present unit are superficial and formal"(19).

It is apparent that these student surveys, carried out in 1962, are a little over-eager to interpret social behavior in a multivariant numerical isolation of the architecture of the new city, and - as is often the case with many of the so-called sociological studies - clearly miss, what Durrell terms "mythopoeic reference which underlies fact"(20). "Inviting"neighbors for tea or dinner, has never been a gesture of Indian hospitality. It manifests itself on "formal occasions": at weddings and childbirths and religious festivals and at times of bereavement; and there are many such occasions even in a small community. And the "superiority of wives and children" is almost exclusively due to the behaviour of their "men" in the offices. Since at various levels of government bureacracies in India the "water-tight compartments" still exist as gloriously as ever, it seems most unlikely - and illogical to expect - however desirable it may be, that these barriers would break down in the residential quarters.

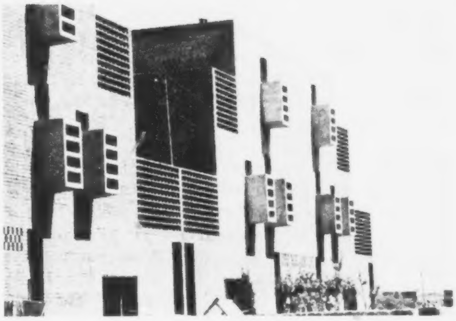
As mentioned before, because of different ways of displaying affluence, in the old towns and villages in India, the various socio-economic groups were not easily visible, though, of course, they existed; but the basis of social-interaction was largely symbiotic rather than equal. In addition, because of small communities, large families, and lack of communication with other communities, the rural and small-town life - with all its gossips and pettiness and fights - was less alienating and so much more communal.

In Chandigarh, the concept of a Sector - a self-sufficient village unit, with a school, a community centre, a shopping plaza and a residential area - was conceived to promote a "community-feeling", within the dimensions of Corbusier's "human scale". But in an economically divergent and "status-conscious" society as Indian, the physical propinquity of a sector-school or community-centre has not enticed people of all levels equally.

Chandigarh, undoubtedly lacks a "civil warmth", which is due largely to the lack of "human warmth" in the Indian bureacracy. In the face of people who steadfastly continue to cling to stultifying social values, no architect-planner can possibly create anything that is likely to make a city "warm". A city acquires the character of her people. Without the human drama, the Piazza San Marco in Venice or the High Park in London, would be little more than museum-pieces.

It has been suggested that "...India is a country where, to a foreigner, it often seems impossible to accomplish anything, and the triumph of Chandigarh is that for better or worse, its founders succeeded in getting it built"(21). But that is not enough! In planning Chandigarh, in spite of many shortcomings, her designers have created essentially a fine, healthy, urban body, but her people will have to fuse the 'soul' they so often find missing in her, to make the city truly "an expression of their creative genius."

An Election Rally



C.S.I.O. Housing

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"THE SQUARE" DESCRIPTIVE MODELING OF CENTRAL COURTHOUSE SQUARE TOWNS OF THE SOUTH CENTRAL U. S.

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Introduction and Objectives

For millions of Americans the most immediate unit of government is the county, which is administered from the county seat. These administrative centers take many urban forms but are most highly structured in the form called "Central Courthouse Square Towns". The traditional center of these towns, "The Square", is described by Dr. Edward T. Price, professor of Geography at the University of Oregon: "A rectangular block surrounded by streets, with the courthouse, often the grandest and most ornate building in the county, standing alone in the middle of the square and the town's leading business houses enclosing the square symmetrically on all four sides."(2)

The rigid order of the square was originally established for the public convenience in a time of horse-drawn vehicles, dirt roads, and the general store. Gradually this way of life has been replaced by the automobile, paved highways, freeways, chain stores, shopping centers, mass communication, and factories. The imposition of a changing way of life upon a form that was conceived as a static order presents a unique confrontation that raises such questions as: how does the need to park the automobile influence the quantity and types of uses of the square?; how does the square respond when a freeway replaces the county road as the major movement artery?; and what new position does the square occupy in the social lives of the local citizens, in view of their greater personal mobility.

While this study does not pretend to answer these questions it recognizes the need for and takes the first steps toward developing a comprehensive data base for such an undertaking. To this end a multi-disciplinary descriptive model has been developed which is capable of providing essential insights into the interrelationships between the social, economic, political, historical and physical components of the square and the surrounding town. These interrelationships are not only the basis for the uniqueness of the central courthouse square town, but a knowledge of them is also essential to an understanding of possible futures of the square.

The study of the square was conducted by a ten man, multi-disciplinary, undergraduate research team sponsored by the National Science Foundation's Student-Originated Studies Program, and The College of Environmental Design at the University of Oklahoma. The project extended over twelve weeks during the summer of 1971. For most of the participants it offered the first non-academic, self-directed opportunity to put to use the skills learned in the classroom. And it not only allowed the participants an occasion to contribute to the understanding of the built environment, but also furnished them with the means to better understand their own and other disciplines.

Since the county seat is an important center in most parts of the United States, and often takes the central courthouse square form in the states east of the Rocky Mountains, making a study such as this would be valuable in almost any region. However, there is a variation of historical, economic, and geographical influences from area to area, causing notable differences in urban patterns. The two major considerations in delineating the region for this study were that the area should be: (a) small enough to allow a meaningful study within the allocated time; (b) as nearly homogeneous as possible, so that generalized conclusions could be draw from a small sample.

The problems of logistics limited the area to one within a maximum of one day's drive from the University of Oklahoma at Norman. This circle was further modified along existing political boundries by geographic, cultural, political, and economic influences. The area which results includes 525 counties in Kansas, Missouri, Oklahoma, Arkansas, and northern Texas. This area is predominantly plains and interior highlands, which are mostly dedicated to agriculture; moreover, the position of the county as a political unit is similar throughout.

Those towns which were recognized as central courthouse square towns and included within the study group were characterized as follows (see figure 1):

a. The courthouse building must be located on or near the center of a park-like block within the county seat town.

b. The courthouse building must be the dominant building on the block upon which it sits.

c. The block upon which the courthouse sits must be surrounded by streets on all four sides.

d. Of each block adjacent to the courthouse block, the side facing the courthouse must be dominated by business establishments.

e. The businesses that are situated as in "d" must now comprise or once have comprised the primary business district of the town.

f. In addition, a working constraint was adopted in the form of upper and lower town population limits of 10,000 and 1,500.

Data Collection

From the 174 central courthouse square towns within the study region, 25 were chosen for field study. Fifteen of these were to be visited for three days and ten for one day each. The number of towns from each state was approximately proportional to the number of central courthouse square towns within the state. In addition, the fifteen to be studied for three days included nine Shelbyville, three Lancaster and three Six-block types. The towns to be visited for one day were of similar distribution for it was felt that this distribution provided ample investigation of the predominant Shelbyville type, while allowing for insights which may arise by including other types.

The field visits were conducted by three man teams, which made maps of the town, interviewed businessmen, officials and local citizens, observed the use of the square, and gathered available published data on the square, town, and county.

Development of the Data Matrix

With the end of the field visits, the task of translating thousands of bits of data into an understanding of the characteristics of central courthouse square towns was undertaken. After experimentation with several possible methods, the use of a data matrix was decided upon as a first step. Each town visited was listed on the horizontal axis and the names of the

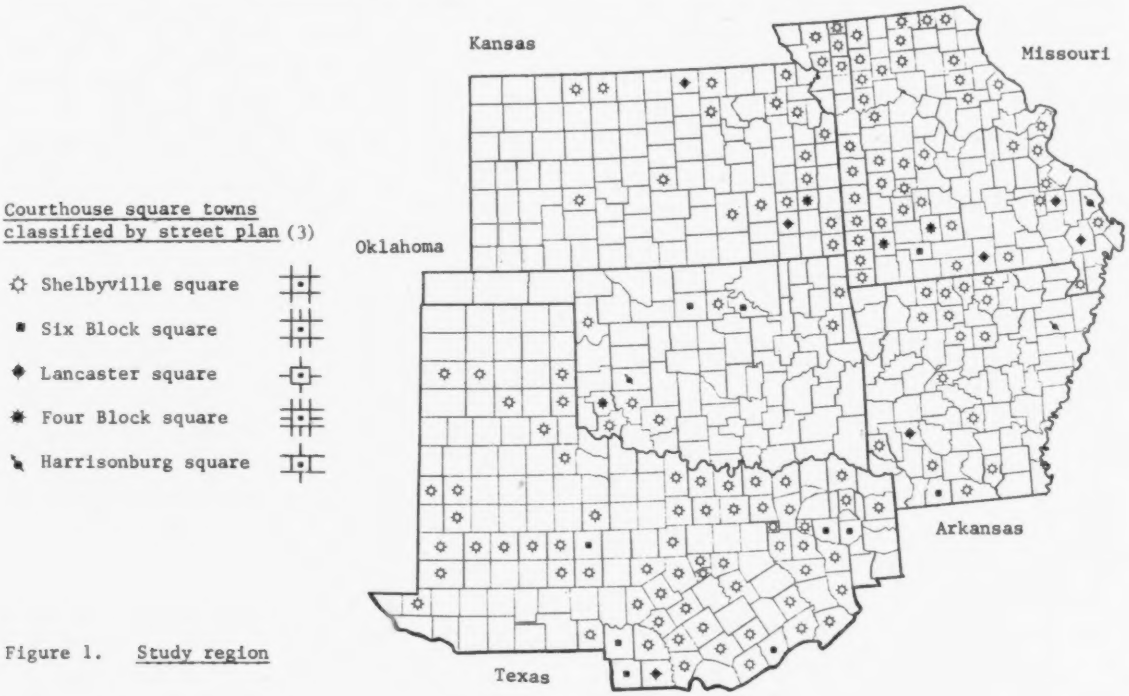
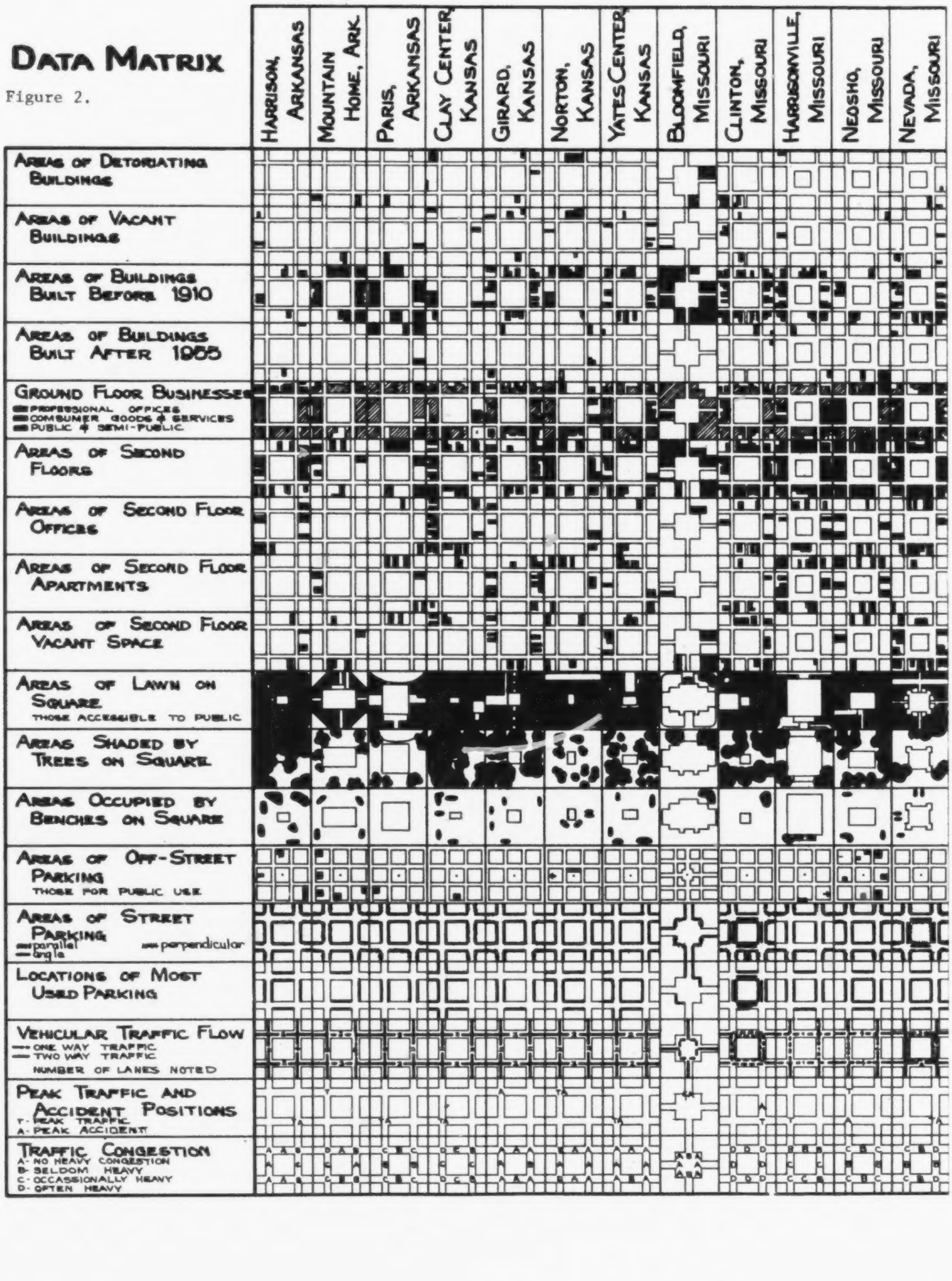


Figure 1. Study region

DATA MATRIX

Figure 2.



Harrison, Arkansas
Mountain Home, Ark.
Paris, Arkansas
Clay Center, Kansas
Girard, Kansas
Norton, Kansas
Yates Center, Kansas
Bloomfield, Missouri
Clinton, Missouri
Harrisonville, Missouri
Neosho, Missouri
Nevada, Missouri
Areas of Detoriating Buildings
Areas of Vacant Buildings
Areas of Buildings Built Before 1910
Areas of Buildings Built After 1955
Ground Floor Businesses
Professional Offices
Consumer Goods & Services
Public & Semi-Public
Areas of Second Floors
Areas of Second Floor Offices
Areas of Second Floor Apartments
Areas of Second Floor Vacant Space
Areas of Lawn on Square
Those accessible to public
Areas Shaded by Trees on Square
Areas Occupied by Benches on Square
Areas of Off-Street Parking
Those for public use
Areas of Street Parking
parallel
angle
perpendicular
Locations of Most Used Parking
Vehicular Traffic Flow
One way traffic
Two way traffic
Number of lanes noted
Peak Traffic and Accident Positions
T - Peak traffic
A - Peak accident
Traffic Congestion
A - No heavy congestion
B - Seldom heavy
C - Occassionally heavy
D - Often heavy

categories of information on the vertical axis. Under each category the data from each town was either depicted graphically or represented by a symbol which corresponded to some characteristic of the town. The construction of the data matrix not only provided a means of viewing the diverse data in juxiposition but proved to be a valuable tool in the process of ideogram formation which followed . (A portion of the data matrix is illustrated in figure 2.)

The need for a notation system

While the data matrix did provide a helpful juxtaposition of the diverse field data, the inconclusiveness of the interrelationships precluded its use as more than an intermediate method of analysis and presentation. In reviewing other means of analysis, the suitability of statistical analysis techniques such as multi-regression and cluster analysis was evaluated. However, the non-numerical and diverse nature of the field data did not provide the quantitative base which statistical methods require. Conversely, the data was too lengthy and interrelated for analysis or presentation in extended narrative. In addition to the above mentioned reasons for not making use of more conventional tools of analysis was a more fundamental and compelling consideration -- the importance of providing a framework within which this study, its findings and their interrelationships could be viewed in a truly multidisciplinary manner. The necessary skills for a multi-disciplinary study were present within the participants; what was now needed was an appropriate medium of communication. It is from this need that the notation system emerged.

The notation system that was developed provided a means of collating the data on each town, correlating the diverse variables and cataloging each town. But beyond listing data, the notation system is also a means of analyzing the interrelationships amoung different types of information, and observing frequencies of interaction, correlation, and occurrence. The following pages present an explanation of the notation technique and utilize it to present and analyze the data collected on central courthouse square towns.

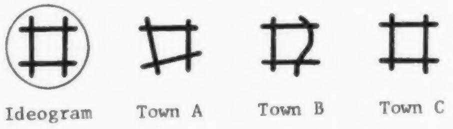
The Notation System

An ideogram, which is the fundamental component of the notation system, describes a concept of one aspect of reality. In formulating an ideogram, the common elements of a number of similar situations are abstraced until the concept which remains - the ideogram - expresses the essence of those situations. The "pure phenomenon" represented in the ideogram need not be present in reality in any given instance, yet all instances which are described by the ideogram approximate in essence the "pure phenomenon".

Ideograms are composed of three parts and are represented as shown in figure 4. The three parts are:

Title.....	A short verbal description of the ideogram
Graphics..	An immediately recognizable symbol which joins with the title to provide a basic understanding of the general topic of the ideogram
Text......	A precise, detailed verbal presentation of a group, type, or tendency

A sample ideogram concerns the street configuration which determines the type of courthouse square town. The most common type of square is the Shelbyville in which the courthouse square is merely one block in a grid street pattern.



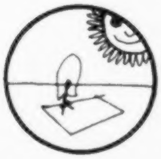
Ideogram Town A Town B Town C

Figure 3.

The researcher formulates the ideogram or "pure phenomenon" of the Shelbyville square by observing a number of courthouse square towns (towns A, B, and C in figure 3). Having observed and compared these towns, the simularities of their street configurations are abstracted and an ideogram formulated which expresses the essence of those configurations. While some towns i.e. A and B are not identical to the ideogram, they hold enough in common with it that they can be classified thus. The "pure phenomenon" need not exist, but may, as in town C.

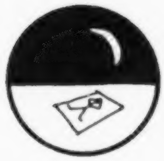
Because of the natural tendency for individual ideograms to form groups which contain alternate possible classes of a given phenomenon, the concept of families was instituted. A family of ideograms consists of a series of ideograms which describe all of the possible alternative situations concerning one aspect of a phenomenon. The ideograms within a family are mutually exclusive, so that every family contains one and only one ideogram which corresponds to the existing situation in a given

Use of the square by children **590**



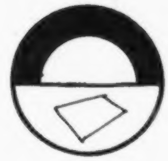
The square is used by children for informal social activity before 6:00 pm.

DURING DAY



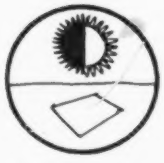
The square is used by children for informal social activity after 6:00 pm.

AT NIGHT



The square is not used by children for informal social activity.

NO CHILDREN



The square is used by children for informal social activity before and after 6:00 pm.

BOTH NIGHT & DAY

Selection criteria:
In order to determine if the square i.e. courthouse lawn, sidewalks, and stores, is used by children under the age of 12 for informal social activities, unobtrusive observations should be made during the morning, afternoon, and night on three different days of the week. (If possible one of the days should be Saturday) An average of five or more children during any of the periods is considered to represent use of the square.

Figure 4. Ideogram family

central courthouse square town. It is important that every recurring phenomenon be covered within a family of ideograms. Therefore, if an alternative not presented by an ideogram within a family recurs frequently, a new ideogram must be formulated to accommodate this new-found alternative. See figure 4 for an example of one of the one-hundred and six families compiled for central courthouse square towns. Note that each family is given a title and a number and that an explanation of terms, procedures, and criteria accompanies each family in order that the process of choosing the appropriate ideogram will be as uniform as possible.

In order to deal with all of the families that have been constructed for central courthouse square towns they are arranged into a chart. The ideogram chart is structured so that families are organized in columns and the towns into rows. The ideogram from each family which best describes the town is indicated by a line through the chart. Figure 5 presents one town traced through a portion of the chart; the entire chart consist of 106 families and 25 towns.

Using the chart for the 25 towns visited, recurring interactions and correlations are noted in order to isolate characteristics of central courthouse square towns. By using the chart of families developed by various disciplines the characteristics which are identified more truly reflect the diverse nature of the towns. The characteristics or recurring interrelationships that are isolated are called "relational descriptions." A "relational description" groups those ideograms that vary together. Since the description includes both the positive and negative relationships formed by interrelated ideograms, all towns will adhere to the model in varying degrees. Thus, the description accommodates several types of conclusions about courthouse square towns. It presents a positive relationship and sets forth the inverse; it incorporates the cases which do not approximate these extremes into the overall statement of relationships by showing that varying combinations of ideograms yield varying tendencies within the relational description.

The relational description assumes causation among ideograms. However, since in many instances the causal agent cannot be isolated, the descriptions merely present the relationship without identifying the causal direction. While a relational description may be formulated without naming the causal direction, future research should be directed toward clarifying the causation.

Listed below are four relational descriptions isolated for the urban form central courthouse square town. These represent the most highly substantiated of the findings.

480	Side of the square with the lowest value
490	Side of the square with the highest value

Family numbers 480 and 490 show a recurring relationship in that there is a high probability that the side of the square with the lowest value will be directly opposite the side of the square with the highest value.

290	Grocery store on the square
870	Population of the county seat

Family numbers 290 and 870 show a recurring relationship in that the greater the population of the county seat, the lower the probability that a grocery store will exist on the square.

60	Most important courthouse entrance
280	People on the courthouse grounds
460	Shopping activity - dominant side

Family numbers 60, 280, and 460 show a recurring relationship in that there is a high probability that all three will occur on the same side of the square.

170	Lawn / courthouse comparison
180	Courthouse grounds reduced
200	Percentage of grounds shaded
280	People on the courthouse grounds

Family numbers 170, 180, 200, and 280 show recurring relationships between the absence or presence of people on the courthouse grounds and the conditions of the courthouse grounds. That is, the smaller the courthouse grounds or the less shaded the grounds, the greater the probability that they will not be used by people for informal social activities.

Even though the data indicated other relational descriptions, these were less conclusive and require further study before they may be considered as denoting meaningful characteristics.

Conclusions

The decisions about the future of the square within any central courthouse square town are in the hands of the local citizens and their representatives, i.e. government officials and planners. But the conscious and unconscious decisions they make can only contribute positively to obtaining the future they desire if those decisions are made within a greater awareness of the distinguishing interrelationships of the central courthouse square town form.

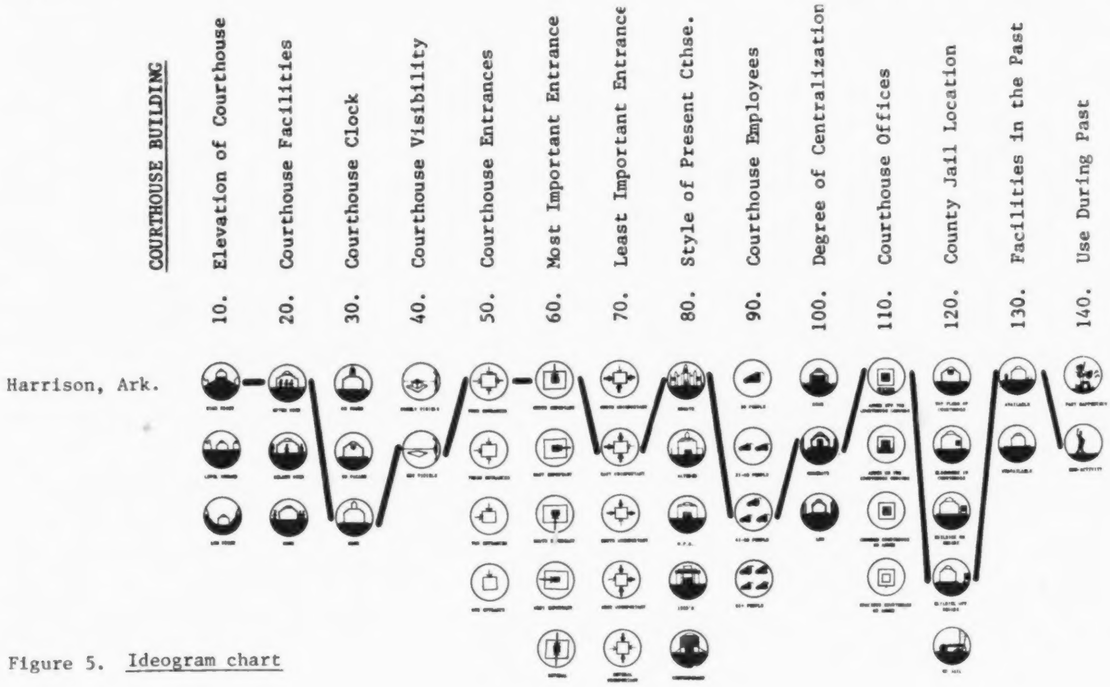


Figure 5. Ideogram chart

It is toward the formation of a general descriptive model that this study has been directed: a model which is built upon the characteristics and interrelationships common to the urban form - central courthouse square town. The notation system used provides a multi-disciplinary language for the model which minimizes the lack of communication between disciplines and lessens the difficulty of holistic conclusions.

Future research on central courthouse square towns should work toward broadening the data base as well as seeking understanding of causal relationships. The notation system within which this research can be continued must first be refined and tested for usefulness as a decision making tool.

Notes

(1) Project participants:

Douglas B. Aikins	Political Sci	Jr.
Wendell H. Boyce	History	Jr.
Kenneth D. Crocombe	Sociology	Jr.
Heiko H. Folkerts	Architecture	Sr.
Robert A. Gifford	Architecture	Sr.
Jude Ann Hamilton	History	Jr.
Barrett L. Kays	Agriculture	Sr.
Russell N. Legg	Geography	Sr.
Neil E. Onerheim	American Studies	Jr.
Dr. Luis H. Summers Associate Professor of Architecture		Faculty Advisor
Edwin R. Warren	Economics	Jr.

(2) Price, Edward T., "The Central Courthouse Square in the American County Seat", The Geographical Review, January, 1968.

(3) Price

THE URBAN ACTIVITY MODEL

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Introduction

A considerable gap exists between our ability to shape, manipulate and control the environment, and our ability to do it wisely. As the problems of the urban environment increase in both complexity and size, and as our growing technological capacity permits us to increasingly bring more vast, rapid and sweeping change upon the urban environment, it also becomes urgently necessary for us to develop tools which aid in the making of intelligent decisions for planned environmental change.

As part of a graduate program in architecture at Rensselaer Polytechnic Institute in Troy, New York, I have developed the initial structure, contents and function of a tool for the analysis of existing urban areas. This "Urban Activity Model" has thus far been employed in analyses of two urban communities, to determine how well or how badly each one fulfilled the needs, desires and life-styles of its residents. The results of these analyses have shown themselves to be of potential benefit to the making of future planning and design decisions for each urban area under study. In addition, a comparison of results from the two analyses has begun to point toward a number of possible trends which, if confirmed, may lead to the development of urban theory and resultant predictive capabilities.

Development of the Urban Activity Model

It was recognized early in the development of the Urban Activity Model, that it would likely need to evolve from being somewhat primitive and unsophisticated to becoming a more versatile and comprehensive instrument. The decision was made, therefore, to consciously build into the Model the capacity to evolve. This was accomplished by placing the three main components of the Model - STRUCTURE, CONTENT and FUNCTION - in a relationship which would permit the Model to grow and change on the basis of its own feedback from analyses of existing urban areas, as well as from externally introduced information.

In essence, the STRUCTURE of the Model consists of the basic concepts which govern the Model. The CONTENTS of the Model are written Performance Statements which are based on the concepts and which express a condition that should exist in the urban environment. The FUNCTION consists of measuring the viewpoints of the residents of existing urban environments against the Performance Statements in order to determine a profile of "Assets" and "Liabilities", i.e., conditions where needs apparently are and are not fulfilled by the urban environment under study.

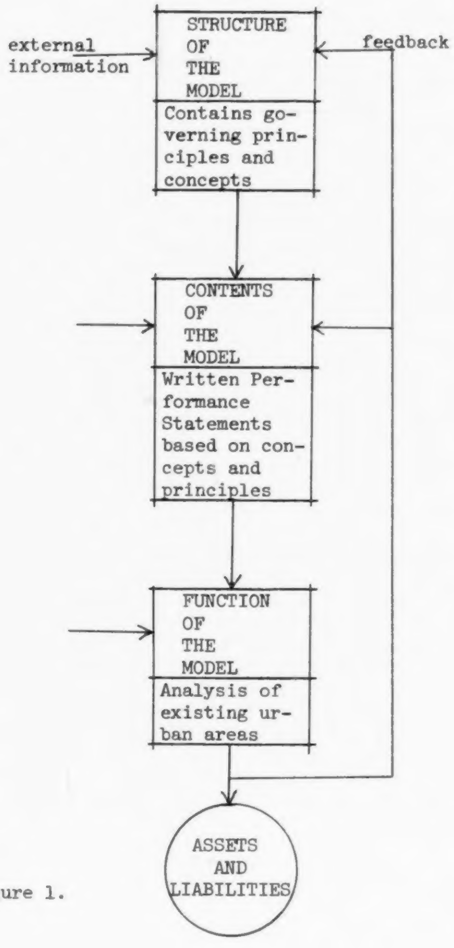

external information
feedback
STRUCTURE OF THE MODEL
Contains governing principles and concepts
CONTENTS OF THE MODEL
Written Performance Statements based on concepts and principles
FUNCTION OF THE MODEL
Analysis of existing urban areas
ASSETS AND LIABILITIES

Figure 1.

As Figure 1. demonstrates, the Model may be updated and modified at the levels of all three of its components without losing its basic configuration or purpose. These updatings or modifications may come from direct feedback of analysis results, or the source may be external, such as new research findings, newly recognized political/social realities, new issues, new techniques of investigation, etc. Both sources of change - internal and external - are likely to have a significant effect upon the present makeup of the Model. As the Model is employed in a number of analyses of existing urban areas, the constant and recurring responses from residents of urban areas will be fed back into the Model to ultimately lead to the formulation of new theory, and possibly to some predictive capability. As new information from external sources is introduced to modify the Model, this current knowledge will permit the Model to be responsive to many of the most recent issues concerning the quality of urban life.

Structure of the Model: Selfhood and Totality
At the present time, the Urban Activity Model's STRUCTURE consists of two concepts: "Selfhood" and "Totality".

The concept of Selfhood is expressed in terms of several "Criteria for Selfhood" which deal with the importance of finding oneself in relation to the larger community. Alienation from others, and from any purposes in life, is not likely to be conducive to a person's interest in shaping a more suitable environment; in fact, it is likely to bring about in people a reduced concern about anything which happens to them or to their environment. The primary quality of urban life must probably be its positive and conscious contribution to the individual's sense of belonging, participation and importance. These, and perhaps additional dimensions not yet considered, define the meaning of Selfhood for the purposes of the Urban Activity Model. The "Criteria for Selfhood" are thus explained as follows:

Age Group Involvement: The urban environment must provide for the needs and activities of all age groups to permit each individual the opportunity to fulfill his needs. This means that the urban environment must provide facilities and other opportunities for the activities associated with each age group, without significant preference of disfavor toward anyone. Included in this concern are the provision of choice among a variety of activities, and of ease of accessibility to the facilities which provide for the carrying-out of these activities.

Involvement of Others: Selfhood is further attained through opportunities for interaction with others, an involvement which fosters mutual recognition. This means that an understanding, an awareness of self, is aided when others acknowledge one's person, or the actions of one's person. This must not only occur between people of the same age, but also to some degree between people of different age groups.

Time Period Influence: The availability of choice among a variety of activities and facilities during all seasons, days of the week and hours of the day, is a prerequisite for the full involvement of age groups and for the optimum interaction among people. Many urban areas are better places to live in during some months of the year than during others; many urban areas are more oriented toward either one of the time periods of the week: weekdays and weekends; and some urban areas are lively only during select periods of time during each day.

Continuity, Stability: The progress of time brings the wear-and-tear of life upon the physical makeup of an urban area - an abuse which must be counteracted every day by service and maintenance activities. But beyond the mere function of continuity of such activities, the constant servicing and maintenance of an urban area's roads, buildings and less visible facilities reflects the existence of selfhood among its residents. The presence of stability and maintenance thus reinforces itself: a well-maintained and well-preserved community is evidence of selfhood in the form of self-respect, while it is at the same time a source of such selfhood for its inhabitants.

Identification, Orientation, Stimulation: The visual configurative appearance of the urban environment contributes considerably to selfhood in the fact that it brings one to identify oneself with a place, and to become identified with a place. Environments which provide exciting, pleasant and memorable visual stimuli, and provide for orientation and place-finding, are likely to also contribute to a person's attainment of selfhood.

In addition to the concept of Selfhood, as articulated above, the concept of Totality is also part of the Model's STRUCTURE. The realization of selfhood through interaction with others takes place in a background environment which is a totality of interdependent activities. This means, for instance, that work cannot be fully understood without leisure, family without community, privacy without interaction, and production without consumption. It means, in fact, that no single factor of urban life can be understood by itself - for the quality of every facet of urban life is affected by the qualities of every other facet. This entirety, this wholeness of urban life, is expressed in the Urban Activity Model in terms of six Urban Activity Categories which reflect the many and varied activities which people carry out in pursuit of their daily lives.

URBAN ACTIVITY CATEGORIES
1.00 Consumption-related Activities
2.00 Celebration and Congregation-related Activities
3.00 Work-related Activities
4.00 Service-related Activities
5.00 Recreation and Relaxation-related Activities
6.00 Communication and Learning-related Activities

Figure 2.

Contents of the Model: Performance Statements

In the development of the Model's CONTENTS, one consideration was important aside from the influences of the "Criteria for Selfhood", and aside from the scope of the Urban Activity Categories: the contents of the Model had to be expressed as a series of measures of performance, regardless of how rough or vague such measures would be. This was necessary if the Model was to function as a means to measure the responses of people in analyses of existing urban areas.

Since such required measures could not be stated in predetermined quantities, a different method of gauging performance had to be employed: a benchmark level of performance would be stated in terms of what people should be able to do, or of what should be, in the urban environment, from the author's point of view. Thus the Model contains a series of positively-written Performance Statements. These Statements, listed below, were generated from the Urban Activity Categories of Figure 2. and they represent individual measures of some of the values expressed in the Criteria for Selfhood.

It must be re-emphasized that the STRUCTURE and CONTENTS of the Urban Activity Model are flexible and subject to gradual evolution. These Performance Statements are therefore not inviolate standards. Instead, they are merely benchmarks against which people will be able to express what may be suitable or unsuitable, worthwhile or worthless, to their daily lives.

Category 1.00: Consumption-related Activities.

1.01 Children are able to perform errands for adults at nearby shops and stores.
1.02 Children are able to set up makeshift roadside stands to sell lemonade, cookies, etc. to passers-by.
1.03 People are able to reach grocery stores by public transportation.
1.04 People are able to drive to a variety of shopping areas to do their grocery shopping.
1.05 People are able to shop for groceries on their way home from work (or have someone else do this for them).
1.06 People are able to walk to necessary grocery stores.
1.07 People are able to window shop.
1.08 People are able to reach a variety of larger department stores by public transportation.
1.09 People are able to reach a variety of larger department stores by driving to them.
1.10 People are able to find parking when driving to shops and stores.
1.11 People are able to eat in outdoor restaurants during the warmer seasons of the year.
1.12 People are able to dine in a variety of restaurants in the larger area of the community.
1.13 Local establishments provide catering/take-out services.

Category 2.00: Celebration and Congregation-related Activities.

2.01 People are able to partake in a variety of programs which bring many people together in the larger area of the community (e.g. concerts, theater, athletic events, etc.)
2.02 People are able to partake with other community members in a seasonal schedule of activities (e.g. art shows, caroling, picnics, festivals, etc.)
2.03 People are able to discuss concerns about the community with friends at meeting places provided for this purpose.
2.04 Children and adolescents are able to partake in the activities of community youth groups.
2.05 People are able to partake in community activities with older people.
2.06 People are able to partake in community activities with younger people.
2.07 People are able to partake in community activities with people of the same age.

Category 3.00: Work-related Activities.

3.01 People are able to walk to and from work.
3.02 People are able to use public transportation facilities to go to and from work.
3.03 People are able to comfortably drive to and from work.
3.04 Children are able to attend day care facilities.
3.05 Children are able to find small jobs in the community.
3.06 Older people are able to find small jobs in the community.

Category 4.00: Service-related Activities.

4.01 Garbage collection occurs frequently and sufficiently without major disruption or traffic or sleep.
4.02 All sidewalks and roads are well-illuminated at night.
4.03 All sidewalks are regularly cleaned by the people in the community.
4.04 All roads are regularly cleaned by the municipality.
4.05 All sidewalks are regularly repaired and maintained by the municipality.
4.06 All roads are regularly repaired and maintained by the municipality.
4.07 People are able to get action on complaints and requests through political channels in the community.
4.08 Ambulances respond quickly and reach their destinations without delays.
4.09 Fire equipment responds quickly and is able to reach an emergency without delays.
4.10 All laws and ordinances are satisfactorily enforced.
4.11 The community's sidewalks are adequate to handle all pedestrian traffic.
4.12 The community provides local outpatient health care.
4.13 The community provides legal aid services.
4.14 The community has an adequate number of practicing physicians to handle all patients.
4.15 The available hospital facilities adequately serve the needs of the community.
4.16 The public schools provide satisfactory education for the children of the community.
4.17 The community provides adequate automobile service facilities.
4.18 The community provides adequate laundry and dry-cleaning facilities.
4.19 The community provides adequate off-street parking for all vehicles.
4.20 Hotels, motels and other overnight accomodations are placed conveniently from the residences.

Category 5.00: Recreation and Relaxation-related Activities.

5.01 People are able to watch traffic and other people from benches or from similar observation places in the community.
5.02 People are able to partake in a variety of indoor and outdoor recreational activities throughout the year within the larger area of the community.
5.03 The community provides for quiet relaxation, especially on weekends.
5.04 The community provides for boisterous, outgoing recreational activities.
5.05 Playgrounds and other recreational areas for children allow for play which is without interference from children of other age groups.
5.06 Children are able to safely ride bicycles in the community.
5.07 People are able to enjoy safe walks in the community.
5.08 People are able to enjoy walks which are visually stimulating.
5.09 The community provides adequately for the keeping of pets without their becoming a nuisance.

Category 6.00: Communication anf Learning-related Activities.

6.01 Elementary schools are located within walking distance from the community residences.
6.02 Children are able to walk to school safely.
6.03 The community is free from persistent foul or annoying odors.
6.04 The community contains a number of characteristic, identifiable smells.
6.05 The community contains places of lively activity.
6.06 The community is free from dominant visual clutter and ugliness.
6.07 People are able to orient themselves easily with the help of signs and symbols when looking for a particular place or places.
6.08 People are able to view exhibits in museums, galleries, etc. in the larger area of the community.
6.09 The community provides adequate library facilities.

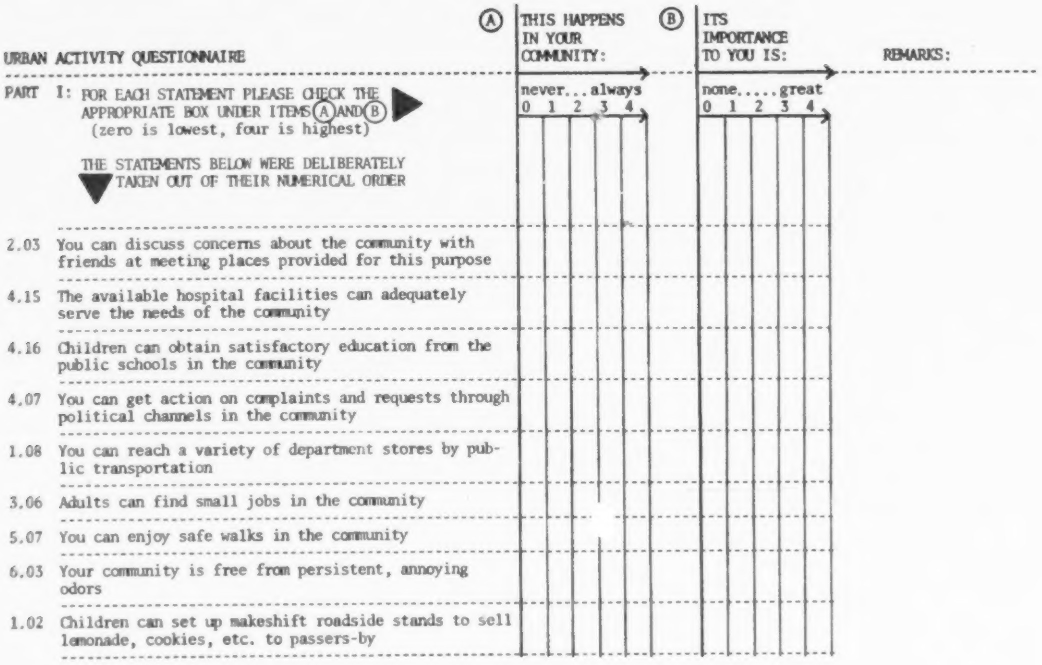
Function of the Model: Analysis of Urban Areas

A questionnaire, based on the previously developed Performance Statements was constructed and administered initially in two urban communities in New York and Maryland. This questionnaire is made up of two parts.

The first part contains the Performance Statements with two rating scales after each statement. Each rating scale has values from zero to four, within which the respondent is asked to give his valuation (1) of the frequency of occurrence in the community and (2) of the importance to him, of the activity described in the Performance Statement in question. The numerical order of the Performance Statements was scrambled in order to randomize the sequence of responses to each Urban Activity Category.

The second part of the questionnaire asks the respondent to give some personal data, to identify landmarks and places of activity in his community, and to describe major attributes and problems of his community.

Consideration was given in the questionnaire format to allow easy transposition of results onto data processing cards. The next page contains a sample page of Part I and the page containing Part II of the questionnaire.

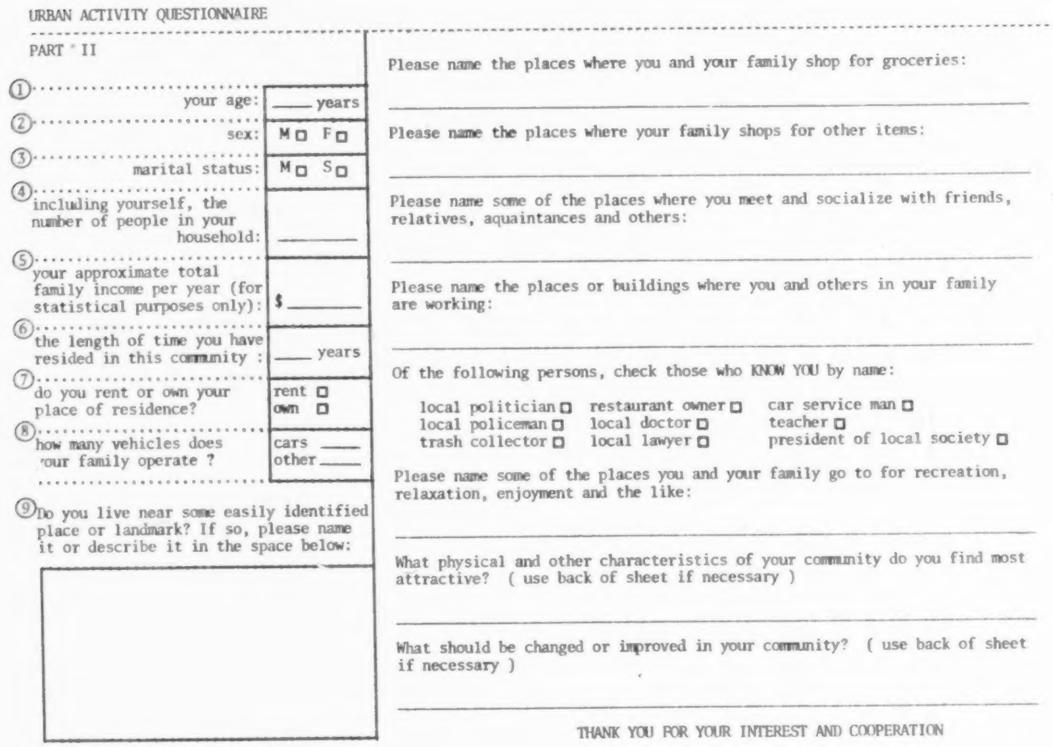


URBAN ACTIVITY QUESTIONNAIRE

PART I: FOR EACH STATEMENT PLEASE CHECK THE APPROPRIATE BOX UNDER ITEMS Ⓐ AND Ⓑ ▶
(zero is lowest, four is highest)

THE STATEMENTS BELOW WERE DELIBERATELY TAKEN OUT OF THEIR NUMERICAL ORDER ▼

		Ⓐ THIS HAPPENS IN YOUR COMMUNITY: never...always					Ⓑ ITS IMPORTANCE TO YOU IS: none.....great					REMARKS:
		0	1	2	3	4	0	1	2	3	4	
2.03	You can discuss concerns about the community with friends at meeting places provided for this purpose											
4.15	The available hospital facilities can adequately serve the needs of the community											
4.16	Children can obtain satisfactory education from the public schools in the community											
4.07	You can get action on complaints and requests through political channels in the community											
1.08	You can reach a variety of department stores by public transportation											
3.06	Adults can find small jobs in the community											
5.07	You can enjoy safe walks in the community											
6.03	Your community is free from persistent, annoying odors											
1.02	Children can set up makeshift roadside stands to sell lemonade, cookies, etc. to passers-by											



URBAN ACTIVITY QUESTIONNAIRE

PART II

① your age: ____ years

② sex: M ☐ F ☐

③ marital status: M ☐ S ☐

④ including yourself, the number of people in your household: ________

⑤ your approximate total family income per year (for statistical purposes only): $ ________

⑥ the length of time you have resided in this community : ____ years

⑦ do you rent or own your place of residence? rent ☐ own ☐

⑧ how many vehicles does your family operate ? cars ____ other ____

⑨ Do you live near some easily identified place or landmark? If so, please name it or describe it in the space below:

Please name the places where you and your family shop for groceries:

Please name the places where your family shops for other items:

Please name some of the places where you meet and socialize with friends, relatives, aquaintances and others:

Please name the places or buildings where you and others in your family are working:

Of the following persons, check those who KNOW YOU by name:

local politician ☐
local policeman ☐
trash collector ☐
restaurant owner ☐
local doctor ☐
local lawyer ☐
car service man ☐
teacher ☐
president of local society ☐

Please name some of the places you and your family go to for recreation, relaxation, enjoyment and the like:

What physical and other characteristics of your community do you find most attractive? (use back of sheet if necessary)

What should be changed or improved in your community? (use back of sheet if necessary)

THANK YOU FOR YOUR INTEREST AND COOPERATION

Figures 3 and 4.

As shown in Figure 3, each respondent is asked to react to the Performance Statements by rating two values: frequency and importance. This dual measure is applied in keeping with the previously stated idea that the Urban Activity Model cannot, at this point, presume to be rigidly prescriptive, and that it must rather be capable of learning from the expressed desires of urban dwellers, and allow such feedback to be considered in future modifications to the Model. Thus the questionnaire allows the Model to become a tool for learning about urban areas, because it determines not only the degree to which a certain activity does or does not occur in a particular urban area; it also determines the relative importance of this activity to the respondents from this urban area.

While it is beyond the scope and intent of this presentation to show the detailed, numerical and statistical parameters employed in obtaining the questionnaire results, it must be pointed out that five distinct relationships between frequency and importance ratings were identified, and the results categorized accordingly.

First, frequency and importance may both be rated significantly high. This indicates that a particular activity not only occurs frequently, but that it is of commensurate importance: a desirable quality, which for the purposes of categorization is termed a FIRST ORDER ASSET.

Second, frequency and importance may both be rated significantly low. This indicates that the particular activity not only occurs infrequently, but that it is equally unimportant. This is also a desirable condition, termed a SECOND ORDER ASSET.

Third, frequency and importance may be rated significantly high and low, respectively. This indicates that an oversupply exists beyond the expressed importance. For example, a high frequency, low importance rating on the statement "People are able to use day care facilities" would indicate that such facilities are known to be available, but that the need for them is for one or another reason less than that for which has been provided. While this relationship between frequency and importance describes conditions of oversupply, they are nevertheless nondestructive and therefore termed THIRD ORDER ASSETS.

Fourth, frequency and importance may be rated neither high nor low, but near the median of both scales. Such an ambiguity must be further investigated, especially for consistency among all age groups and other special interest groups, but because of its generally harmless characteristics, it is termed a FOURTH ORDER ASSET.

Fifth, frequency and importance may be rated low and high, respectively. This signifies the only definite destructive or harmful condition, in that a lack of provision for the activity exists in the face of high importance to the respondents. This is a potentially or actually harmful condition, a LIABILITY.

For each of the analyses of existing urban areas accomplished thus far, these Assets and Liabilities were listed and further categorized by individual responses of (1) age groups; (2) marrieds vs. singles; (3) males vs. females; (4) income groups; (5) length of residence; and other desirable, practical and worthwhile subdivisions. Figure 5. below depicts this information as it relates to the early steps of the process of planning, programming and design in the environment, as a possible sequence leading to the development of an action program for an existing urban area.

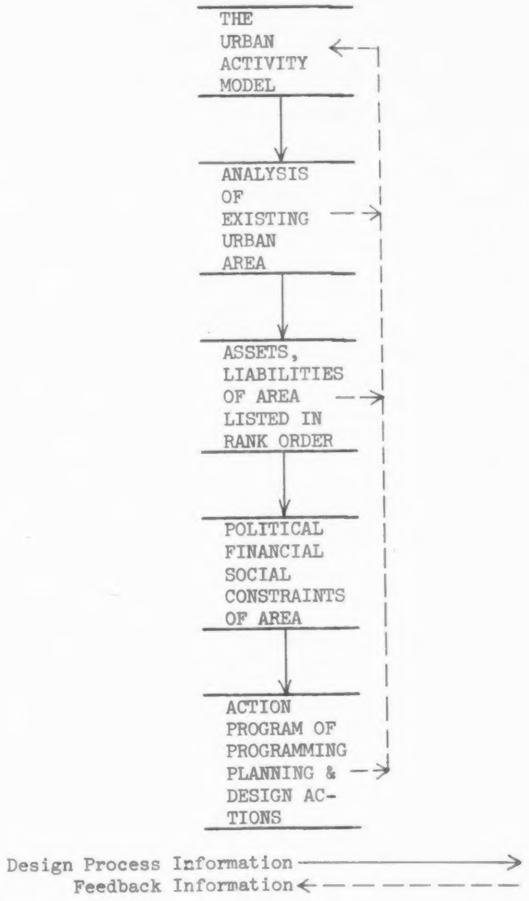

THE URBAN ACTIVITY MODEL
ANALYSIS OF EXISTING URBAN AREA
ASSETS, LIABILITIES OF AREA LISTED IN RANK ORDER
POLITICAL FINANCIAL SOCIAL CONSTRAINTS OF AREA
ACTION PROGRAM OF PROGRAMMING PLANNING & DESIGN ACTIONS
Design Process Information
Feedback Information

Figure 5.

Summary of Results

The two analyses completed to date are of urban communities of an outwardly opposite character.

The community of Lansingburgh, New York (pop. approx. 20,000) is located north of the center of the City of Troy, whose total population of 62,000 includes that of Lansingburgh. The site of Troy and Lansingburgh is bounded by the Hudson River to the West, and to the East it occasionally overflows up a steep grade, approximately one half mile from the riverfront. As a consequence, Lansingburgh has expanded generally northward, following a rectangular grid pattern of streets. Several parks and open spaces are contained within this grid, but the riverfront is undeveloped for recreation. While no true boundaries exist between Troy and Lansingburgh, many residents have quoted 101st Street as the "line". The city government of Troy, including police, fire department and municipal services, has jurisdiction over Lansingburgh. Lansingburgh's Public Schools and its public libraries are, however, separate from those of Troy. The reasons for this condition are explained as follows: Lansingburgh was founded 200 years ago on farmland owned by the Lansing family. This founding preceded the origin and development of Troy by approximately fifty years. Eventual circumstances, having to do particularly with the construction of the New York State Barge Canal and the consequent changes in navigation of the Hudson River, led to a more strategic position of Troy, to its faster growth, and to Lansingburgh's incorporation into Troy's boundaries. (The official Post Office address is "North Troy", not Lansingburgh.) Some not too overt resentment over Lansingburgh's lack of independence is yet evident, along with overt pride in those matters over which Lansingburgh exercises its own jurisdiction (such as the schools and libraries). The community's past is rich with the history of the past two centuries, especially the Revolutionary and Civil War periods, and Herman Melville lived here for a few years of his life - further sources of pride. While Troy developed into an industrial town (collars, cuffs, surveying instruments, iron and steel works and some grain mills), Lansingburgh became primarily a fashionable residential community supportive of Troy. Some stately town houses and mansions are in evidence from this time, and the character of the community is dominated by large two story single and two family homes. A number of secondary industries have since moved into Lansingburgh taking such forms as dry cleaning plants and automobile dealerships. On the whole, however, Lansingburgh remains an integral residential community, containing many of the essential commercial, educational and recreational facilities.

The large part of Bowie, Maryland is a nine year old community of approximately 30,000 inhabitants. It consists of approximately 7,000 single family dwellings, stretched out over a rolling countryside near the center of a triangle between Washington, Baltimore and Annapolis, whose industry and commerce and business it generally supports as a bedroom community. These homes were built by Levitt and Sons, Inc. of Levittown fame, who also built the roads and set aside areas for shopping centers, schools and churches, as well as for some later constructed recreation areas (pools and tennis) with private membership. The roads are arranged in a random, spiderweb-like pattern which sometimes follows the contours of the land, with the advantage of avoiding uniformity, monotony and drag-racing, but which makes it often difficult to orient oneself. Nine years ago, Bowie was a small village with a railroad freight yard and a cement factory, and with some farmland. Nearby was an all-black Teachers College and a regional horse race track. This old part of Bowie is presently a mere appendage, the Teachers College is integrated and the race track is flourishing.

The respondents of the Bowie questionnaire sample were less heterogeneously grouped than in Lansingburgh: Bowie showed no low income group (below $ 8,000 per year), and no single adults were represented in the Bowie sample.

The questionnaire results for each community yielded Assets and Liabilities ranked, as previously described, from the responses to the questionnaire. These results have been documented and communicated to planning and other officials in both communities.

In addition to these results, a comparison of the responses from the residents of Lansingburgh and Bowie brought about the realization that, inspite of the different environments which they represent, their residents seem to place very heavily the same importance on the same things. The proof of this lies in the manner in which the residents of both communities rated the Performance Statements.

Twenty-five Performance Statements were rated as FIRST ORDER ASSETS by residents of both communities, which means that in each case they had to indicate a high importance rating. Twenty Performance Statements were rated as FIRST ORDER ASSETS by one community and as LIABILITIES by the other, which again means that the respondents from both communities had to place high importance on these statements. In addition, four Performance Statements were rated as LIABILITIES by both communities, again indicating that the respondents felt these issues to be highly important. As a result, forty-nine of sixty-four Performance Statements were rated of high importance by the respondents from both communities.

This points out, perhaps, that the originally developed sixty-four Performance Statements are strongly indicative of what people seem to prefer in their environments. It is probably too early to conclude from this information that the value systems of both communities are perhaps completely independent of the physical makeup and history of each community. But even the possibility of this is nevertheless an exciting prospect.

It would probably be also premature at this point, at only the completion of two analyses, to draw conclusions which would be used as urban theory from hereon. It is, however, possible to state, cautiously, some hypotheses which may eventually be of service in the formulation of urban theory.

To begin with, based on evidence from the two surveys, I believe that children and adolescents show themselves to be rather consistently more aware than adults of the visual subtleties of their surroundings, and they appear to be more sensitive toward their relationships with other people. Some sample adolescent commentary includes "We ought to 'tone down' the gas stations and the hamburger joints where I live, and maybe everywhere else"; "Our neighborhood looks like a permanent amusement park"; "People here just sort of live next to each other as if that didn't mean anything". While this commentary may have originated with adults, the younger people passed it on, while the older people did not.

Second, women seem to consistently - and perhaps expectedly - show themselves to be substantially more concerned about children than men.

Third, there appears to be little significant difference between the overall desires of married versus single persons, except when matters concerning children seem to be involved. This does not mean that the actual activity patterns of married and single persons are necessarily the same, only the desires are.

Fourth, there exists the possible condition that low income families and high income families have some different attitudes with regard to their personal involvement in community activities. People with high incomes generally seem to place high importance on participation in community affairs and activities, while low income respondents felt this was less important to them.

Fifth, people with higher incomes appeared to be generally more protective of their children. One case in point is the Performance Statement referring to children being able to safely ride bicycles in the community. On that issue, low income families rated this as an Asset (safe and important) while high income families felt that it was a Liability (unsafe, but important).

Sixth, low income people placed higher importance than others on being able to use public transportation facilities, and on having shops and stores closer to home.

Seventh, although the automobile's mobility is foremost in the minds of adolescents and adults, this has seemingly not eliminated the desire of persons to perform activities by other modes of transportation, including walking.

Eighth, people generally seem to prefer to associate with people of their own age, and only secondarily do they seem to want to associate with younger or older people. This pervades all age groups, except that older persons have expressed some reluctance to associate with younger people at all.

These hypotheses merely hint at some of the knowledge which may perhaps be developed by the pursuit of the type of inquiry illustrated in this presentation.

Conclusion

The research work outlined above shows the development of a procedure for determining some of the social and physical requirements of an urban area for the purpose of decision-making in planning, programming and design tasks. Perhaps the most important aspect of this procedure is that it is presented as part of the process of planning, programming and design which occurs, consciously or not, in every urban area.

The process of analysis of existing urban areas, along the lines described herein, must be constantly refined and repeated with a larger number of urban communities. The results of such additional analyses must then be examined for similarities and differences, and for identifiable trends which may lend themselves to the consequent formulation of urban theory.

11: TRANSPORTATION NETWORKS

RELATING URBAN DESIGN TO THE MOTORIST: AN EMPIRICAL VIEWPOINT

Leslie S. Pollock

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Design principles related to the motorist's perception of the urban environment are sorely lacking in the urban design vocabulary. Such an omission is, in part, related to the architectural origins of urban design, for the architectural scale is historically related to the pedestrian rather than the motorist. However, it is mainly due to the paucity of design theory related to the motorist's perception of the physical conditions surrounding the road. This is a notable problem when viewed within the context of the time an urban resident spends in the automobile and the power that this machine has had in shaping our urban pattern.

That such a gap exists does not deny the fact that there is considerable interest in designing an environment related to the motorist. However, the published studies that discuss the motorist's visual relationship to the surrounding environment tend to deal with subjective interpretations of the view from the automobile or with principles related to the design of buildings in terms of the service needs of traffic (1). There are few major studies, however, which attempt to delineate principles related to the motorist's view of the city and the consequences this view has upon motor vehicle operation (2).

It is the purpose of this paper to contribute towards fulfilling this need by objectively studying the relationship between the motorist and his surrounding environment. The analysis reported here has attempted to provide some general design principles based upon an empirical inquiry into the distractive effect of the urban environment upon motor vehicle operation. Its findings are broad and inconclusive. However, they do indicate that there is a valid need for such principles since the motorist's visual and perceptual requirements are different from those of the pedestrian, and this difference is critical to the safety of the motorist.

A most important factor accounting for the differences between the relationship of the motorist and pedestrian to their surrounding environment is the amount of time each has a similar object or scene within his field of vision. The time the pedestrian spends on the perception of a certain scene is based upon his own interest and desire, whereas the motorist only has the same scene in his field of vision for a time directly related to the speed of his automobile. This time difference and the conditions under which an object is viewed are the elements which constitute the critical difference between the perceptual requirements of the motorist and the pedestrian.

Neither of these elements are really critical to the pedestrian's perceptual processes, for he can vary them to suit his needs. The motorist, however, has a direct, critical relationship for they are the limits, the given conditions, upon which his exposure to all forms are based. Because of these limitations--the restricted perception time and field of vision--the motorist requires a different set of design criteria to enable him to perceive safely the surrounding environment. This need to perceive the environment safely is a factor that is not considered in the perceptual needs of the pedestrian. Driving an automobile, however, is a complex task which requires skill and strict attention to the road. But, all drivers tend to mitigate this task with a visual scanning unrelated to it. Such scanning can be viewed as a potential traffic hazard that endangers the driver's safety. In order to reduce this potential hazard, and hence increase driving safety, the elements viewed should be based upon design principles that are related to the driver's perceptual requirements.

To effectively evaluate the possible impact of the motorist's surrounding environment and to provide insights into how to correct it, an attempt was made to relate specific motor vehicle accidents to the structure of the visual environment. The basis for this investigation was accident and environmental data drawn from selected arterial street sections in Chicago, Illinois. Briefly, the study was structured in the following manner. Physical and psychological relationships between the driver and the physical environment were established from an analysis of the driving task and the psychology of perception. These relationships were used to formulate hypotheses which posited the distractive implications of particular elements of the environment (e.g., building setback) on the motorist. The validity of the hypotheses was tested by correlating elements of the physical environment with specific motor vehicle accident types that could be attributed to distraction. The results of this procedure was then used to draw conclusions from which some general design principles have been derived.

Hypotheses of Driver Distraction

Research into the psychological and physical aspects of the driving task has shown that certain driver related operations--vehicular navigation, the location of destination and visual curiosity--are almost entirely related to the perceptive ease of the environment as seen from a moving vehicle (3). Moreover, it has been found that the efficacy of these operations is related to the efficacy of the driving task itself. Although such visual operations of the driving task are dependent upon the driver's accurate perception of the surrounding environment, the structure of the environment may reduce the driver's ability to interpret them. This conflict between environmental needs has led to the following observation:

> Certain motor vehicle operating requirements could result in the distraction of the driver from his primary task of vehicular manipulation. Such distraction may be caused by a perceptual difficulty in sensing the environment surrounding the road created either by the structure of the environment or the limitations imposed upon the driver by his task.

The hypotheses formulated to test this observation evaluated the effect of measurable changes occurring in the structure of the driver's visual field upon his capacity to operate an automobile safely. These changes have been analyzed in terms of the driver's clear, or foveal, visual field--the area of greatest visual acuity wherein all elements appear clearly defined--and the peripheral field wherein the driver cannot differentiate elements unless he turns his head away from the road. Figure 1 illustrates the relationship of both of these segments of the driver's visual field. The relationships covered by these hypotheses can be summarized as follows:

> In any selected area (usually one-half mile in length):
>
> As the mean of all building setback distances decreases and the standard deviation around the mean decreases, accidents should increase.
>
> As the difference between the shape of the visual field on either side of the driver increases accidents should increase.
>
> As the distance between peripherally viewed objects and foveally viewed objects increases, accidents should increase.
>
> As the standard deviation around the mean building height increases, accidents should increase.
>
> As the difference between adjacent setback distances continues to increase, accidents should increase.

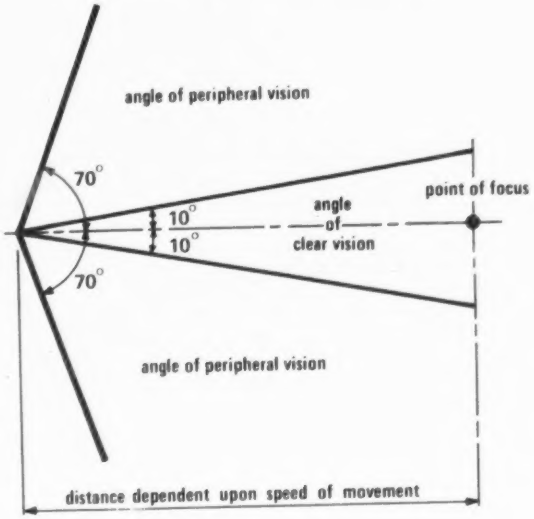

angle of peripheral vision
70°
10°
10°
angle
of
clear vision
point of focus
70°
angle of peripheral vision
distance dependent upon speed of movement

FIGURE 1

THE MOTORIST'S VISUAL FIELD

Data Collection Procedures

To evaluate these hypotheses the specific sites to be studied were controlled so that all variables were constant except accident rates and the structure of the environment. Table 1 contains the constraints placed upon accident location and type to facilitate this control.

Given the additional limitations of daylight, clear and dry weather, and the restriction that the driver must be in a physical condition conducive to good driving behavior (e.g., not drunk or handicapped), a population of accident locations was selected from data supplied by the Chicago Area Transportation Study, the Chicago Police Department, and the Chicago Bureau of Street Traffic. A stratified sample approximating the population's accident rate distribution was then drawn for analysis purposes (4).

Given this sample of accident locations, variables were developed and calibrated to statistically test the hypotheses of driver distraction. The procedure used for this purpose measured the changes occurring in the shape and structure of the driver's visual field as he passed through a previously determined "accident zone." The following discussion describes this analysis procedure and the results of its application.

Table 1
CONDITIONS REQUIRED FOR ANALYSIS

Requirement	Reason for Use
Accident studies must have occurred on arterial streets.	Arterial Streets Exhibit: - A high level of accident occurrence. - High traffic volumes (two-lane A.D.T. = 5,000 - 9,000) and are the major elements of the urban street system. - Restrictions on parking. - Front building lines that are usually coterminous with the front property lines, thereby surrounding structures within easy view of the driver.
Accident types studied have been limited to front, rear and fixed object collisions not occurring at an intersection and involving at least one party who is not a resident of the metropolitan area.	Front, rear, and fixed object collisions tend to lend themselves to occurrence by distraction whereas other accidents such as "sideswiping" and right-angle collisions seem to bear a more direct relationship to problems of traffic flow. Collisions that do not occur at intersections are related to driver awareness and are not generally affected by traffic movements outside of the driver's field of vision. Accidents where at least one party involved is not a resident of the metropolitan area assumes that this driver is fairly unfamiliar with the area and that he might be distracted by looking at his new surroundings. This has enabled the researcher to discount the reactions of the habitual traveler of a selected route who may know the route and would not necessarily be affected by the environment.
Accident locations analyzed in this study must have occurred on portions of the arterial street system which contains the following:	
- A built-up area with a minimum building setback line.	This has been required due to the need to place the surrounding physical elements within the driver's clear field of vision.
- Built-up areas surrounding the roadside of varying intensity and character of development. To be considered as "built-up," at least 50 percent of the street frontage should be occupied by buildings.	Such areas have been found to be necessary for comparison of different types of forms and backgrounds upon the driver's view.
- Long (approximately one-half mile) sections of street that are not interrupted by intense volumes of cross traffic emanating from intersecting streets or large traffic generators. Such areas also should demonstrate the following: 1. A low pedestrian activity. 2. A vehicular speed limit of 30 M.P.H. 3. A legally enforced absence of parked vehicles along the street. 4. An absence of traffic signals within the sections. 5. A movement time factor of 44 feet per second. This factor is calculated by dividing the link length by the observed travel time. 6. A low level of traffic congestion and traffic overload as measured by the Congestion Index (C.I. = Street Design Capacity/A.D.T.). This factor should be approximately equal to or greater than one.	These conditions are required to assume similar traffic conditions in all study areas.
Areas of differing land-use.	This allowed for comparison of similar physical forms resulting from dissimilar land-use activities, so that any resulting distractive effect could be related to the forms and not the land-use activity.

The limits of the driver's visual field are determined by his speed of movement, the limitations of his task, and the interior environment of his vehicle. Considering a standard automobile and an attentive driver moving at 30 mph, his visual field, illustrated in Figure 2a, consists of a 20-degree field of clear vision and a 140-degree field of peripheral vision within which he focuses on a point 750 feet ahead (5). Within an urban arterial street, however, this field is not usually structured as in Figure 2a, for the buildings surrounding the roadway create horizontal and vertical limitations upon the shape of the field. As such, objects surrounding the road form definite "givens" in structuring the visual field of the driver. The effect of building location on the shape of the driver's visual field is depicted in Figure 2b.

The field illustrated in Figure 2 is static--it merely represents one point in time--whereas the motorist has a constantly changing field of vision. To simulate this changing field, a technique was derived whereby a number of fields, representing different points along the motorist's path, could be plotted and used for analysis.

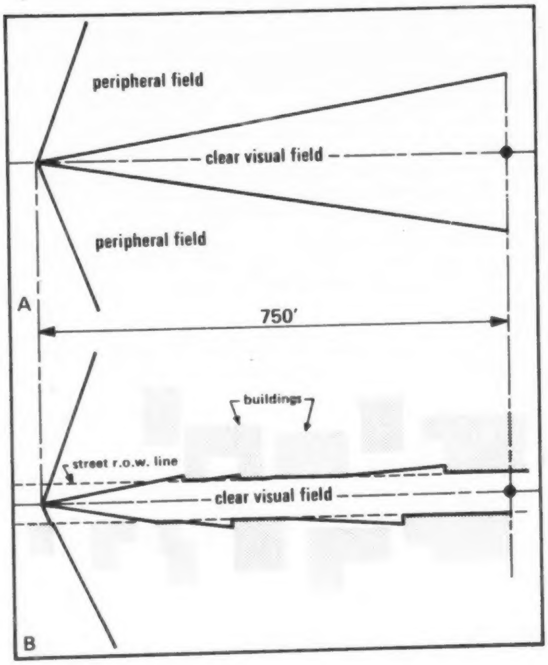
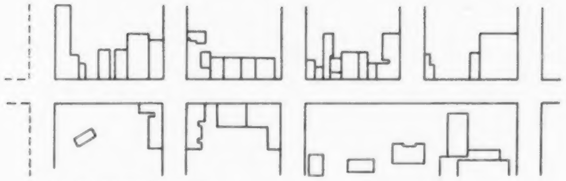


FIGURE 2

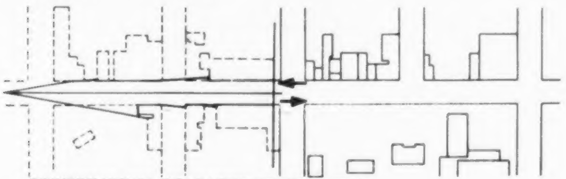
THE THEORETICAL AND ACTUAL VISUAL FIELDS AT THIRTY MILES PER HOUR

To understand this process, consider a front, rear, or fixed object collision arising from driver distraction as assumed in the hypotheses. One may assume that the distracting elements of the environment responsible for this were not located at the specific point of collision, for the objects may have been located ahead or behind the point of impact. If one assumes that the driver was distracted by an object ahead of the point of collision, this object was conceivably located within the distance limits corresponding to the length of the visual field immediately following the point of impact, or 750 feet beyond the accident site. Conversely, if the driver had been distracted by an object appearing before the point of impact, the location of this object was conceivably within the visual field terminating at the point of impact, or 750 feet before the accident. Implied within these limits has been the assumption that both the object and the point of collision were within the driver's field of vision, although they were not necessarily contiguous. Therefore, it might be postulated that the distracting object lies somewhere between a line 750 feet either side of the point of collision. The problem is to simulate the driver's changing field of vision over this distance.

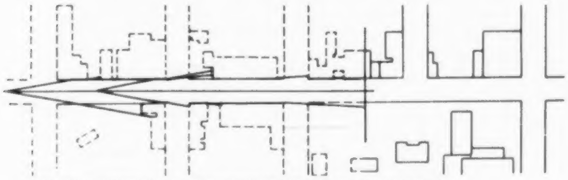
The time necessary to traverse 750 feet at 30 mph is approximately 17 seconds. During this time, the driver's visual field can change shape many times. As the shape of the field is contingent upon the form and location of structures surrounding the roadside, the significant changes in the visual field are directly related to the size and form of these structures. Analysis has indicated that after 2.5 seconds of movement, the shape of the driver's visual field was substantially altered. As such, a 1,500-foot dynamic visual field was plotted around each accident zone, and it was measured in 2.5 second intervals to simulate the changing shape of the driver's field of vision. This is illustrated in Figure 3 where the progression of 2.5 second interval fields is depicted. Within this dynamic visual field, data was gathered indicating the setback distances and heights of objects that the driver could see clearly and peripherally. Seven static fields were measured to account for the significant change every 2.5 seconds during the 17+ seconds of movement. These data formed the base for the analysis of the effect of environmental structure upon the motorist's driving capability. The summary variables derived from these data are described in Table 2.



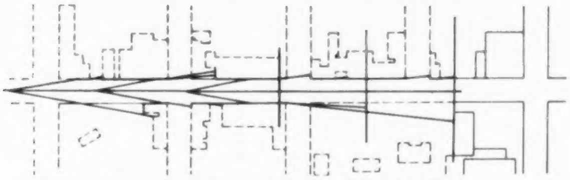
PLAN OF ACCIDENT ZONE



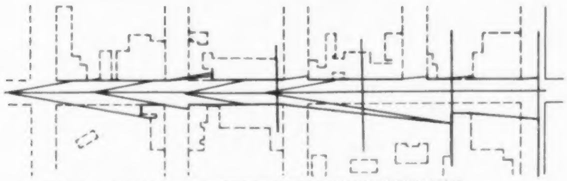
DRIVER'S VISUAL FIELD UPON ENTERING ZONE



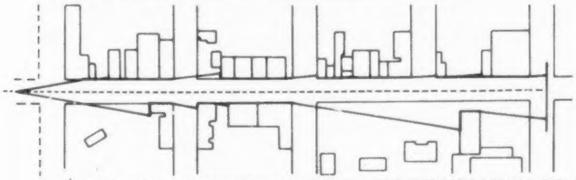
DRIVER'S VISUAL FIELD AFTER 5 SECONDS OF MOVEMENT



DRIVER'S VISUAL FIELD AFTER 10 SECONDS OF MOVEMENT



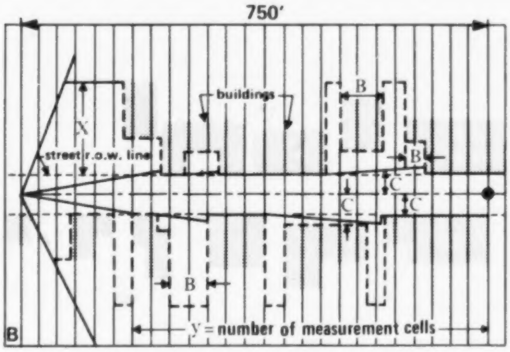
DRIVER'S VISUAL FIELD AFTER 17 SECONDS OF MOVEMENT



SUMMARY OF THE DRIVER'S VISUAL FIELD----THE DYNAMIC VISUAL FIELD

FIGURE 3

THE CHANGING SHAPE OF THE DRIVER'S VISUAL FIELD



A = NUMBER OF STATIC FIELDS MEASURED IN EACH ACCIDENT ZONE

MEAN DIMENSION OF CLEAR VISUAL FIELD WIDTH OR HEIGHT

$$W = \frac{\Sigma\left(\frac{\Sigma C}{y}\right)}{A}$$

DEVIATION AROUND CLEAR VISUAL FIELD MEAN

$$D = \frac{1}{A}\sqrt{A\left[\Sigma\left(\frac{\Sigma C}{y}\right)^2\right] - \left[\Sigma\left(\frac{\Sigma C}{y}\right)\right]^2}$$

COIFFICIENT OF VARIABILITY IN CLEAR VISUAL FIELD

$$V = \frac{D}{W}$$

MEAN DIMENSION OF TOTAL VISUAL FIELD

$$E = \Sigma\left[\frac{\Sigma[(X)(B)]}{\Sigma B}\right]$$

DEVIATION AROUND TOTAL VISUAL FIELD MEAN

$$G = \frac{1}{A}\sqrt{A\left[\Sigma\left(\frac{\Sigma(X)(B)}{\Sigma B}\right)^2\right] - \left[\Sigma\left(\frac{\Sigma(X)(B)}{\Sigma B}\right)\right]^2}$$

COIFFICIENT OF VARIABILITY OF TOTAL FIELD

$$H = \frac{G}{E}$$

RATIO OF CLEAR TO TOTAL FIELD

$$R = \frac{[\Sigma(X)(B)][y(A)]}{(\Sigma B)(\Sigma C)}$$

RATIO OF CLEAR TO TOTAL FIELD DEVIATION

$$S = \frac{y\sqrt{\Sigma B(\Sigma X^2) - (\Sigma X)^2}}{B(A)\sqrt{y(\Sigma C) - (\Sigma C)^2}}$$

RATIO OF CLEAR TO TOTAL FIELD VARIABILITY

$$T = \frac{A\left[\sqrt{\Sigma B(\Sigma X^2) - (\Sigma X)^2}\right][\Sigma C]}{(\Sigma X)(B)\left[\sqrt{y(\Sigma C^2) - (\Sigma C)^2}\right]}$$

*ALL EQUATIONS HAVE BEEN USED TO MEASURE THE CHANGES IN THE HEIGHT AS WELL AS WIDTH OF THE VISUAL FIELD

TABLE 2

SUMMARY VARIABLES OF ENVIRONMENTAL STRUCTURE*

Analysis Procedure

The resulting data gathered from both collection procedures was then evaluated through the use of the Pearson Product Moment Correlation technique which provided a measure of the association between accident rates and the previously discussed environmental variables. This procedure was applied in two stages. First, a zero-order correlation was run on the summary variables to screen out any that did not appear to associate with accidents.

From the results of this correlation, shown in Table 3, any variable that exhibited $r \geq 0.3$ was selected for a multiple correlation analysis used to test the strength of the previously described hypotheses.

The second stage of the correlation analysis evaluated the summary variables selected as indicators of distraction through a multiple correlation technique which measured the degree of association between the dependent variable--accident rates--and any number of independent variables--selected variables measuring the shape of the driver's visual field.

Table 3
ZERO-ORDER CORRELATION COEFFICIENTS OF INTERVAL VARIABLES

	Width			Height		
	Left Side	Right Side	Both Sides	Left Side	Right Side	Both Sides
Mean dimension of clear visual field (W)	.59 (6.92)	.40 (2.48)	.54 (5.30)	.30 (1.28)	.20	.29
Deviation around the clear visual field mean (D)	.57 (6.11)	.06	.33 (1.60)	.04	.08	.04
Coefficient of variability in clear field (V)	.55 (5.57)	.01	.25	.43 (2.85)	.09	.18
Mean dimension of total visual field (E)	.38 (2.11)	.03	.24	.05	.24	.14
Deviation around the total visual field (G)	.30	.13	.09	.01	.30 (1.28)	.04
Coefficient of variability in total field (H)	.04	.15	.01	.16	.11	.16
Difference between clear and total visual field dimensions (R)	.26	.35 (1.77)	.44 (3.04)	.51 (4.56)	.08	.36 (1.94)
Difference between clear and total visual field mean deviation (S)	.44 (3.04)	.10	.17	.50 (4.33)	.21	.40 (2.47)
Ratio of clear to total visual field variability (T)	.40 (2.47)	.22	.12	.36 (1.94)	.44 (3.04)	.08

NOTE: Values = 0.3 contain values of F Test of statistical significance. At the 0.05 level of significance, F = 4.84 (paranthetical values equal value of F).

Using this technique, variables demonstrating an $r \geq 0.3$ were grouped into sets that could be presumed to explain the hypotheses (6).

The results of both the correlation procedures were then subjected to the standard F test in order to determine their statistical significance. The application of this test demonstrated statistical significance, at the five percent level, for a number of correlations. This implied that, for the results stated in Table 4, there is only a five percent change that we could have obtained the given value of (r) or larger (in absolute terms) if there were actually no linear association between accident rates and the structure of the visual field as measured by the selected variables.

Table 4
HIGH CORRELATION VARIABLES DEMONSTRATING SIGNIFICANCE AT THE FIVE PERCENT LEVEL

Zero-Order Correlation Coefficients ($p = 0.05$)			
^{W}Width Left Side		=	-.59
^{W}Width Both Sides		=	-.54
^{D}Width Left Side		=	-.57
^{V}Width Left Side		=	-.55
Multiple Correlation Coefficients ($p = 0.05$)			
^{W}Width Left	^{W}Width Right	=	.64
^{W}Width Left	^{W}Width Both	=	.64
^{T}Height Left	^{T}Height Right	=	.62

An analysis of the variables measuring incremental changes in the shape of the motorist's visual field was also undertaken. Unlike the analysis of the summary variables, this analysis was not statistical but merely an investigation of plotted curves identifying changes in the width and height of the motorist's visual field. The results of this analysis has shown that within each accident zone the shape of the right and left sides of the driver's visual field varies considerably. One side of the street always appears dominant in the determination of the average shape of the field. The driver's visual field never expands equally on both the right and left side of the driver's line of visual regard, but always expands or varies more on one side than the other. It should also be noted that the driver's peripheral field usually changes shape dramatically between 12 seconds prior and up to the point of collision. This change always takes the form of restricted field width that is not accompanied by a visual transition. The field does not slowly compress but rather takes a discrete plunge from wide to narrow or vice versa. One can see, therefore, that there is a tremendous variation in the total visual field as well as a lack of a relationship between what the driver sees and what exists in the total visual environment.

Results

Results of the correlation analysis listed in Table 4 and the incremental analysis described above imply that the following hypotheses may be valid:

> As the mean of all building setback distances decreases and the standard deviation around the mean decreases, accidents should increase.
>
> As the difference between the shape of the visual field to either side of the driver increases, accidents should increase.
>
> As the standard deviation around the mean building height increases, accidents should increase.

This investigation represents a preliminary step in the determination of design principles related to the visual needs of the motorist. Its greatest success lies in establishing that there appears to be a need to intensively study the design premises related to the moving observer since the design of his environment may have an impact on his functional capacity as a motorist. The strength of this finding, however, is unknown, for the analysis explained in the preceding pages is such that one cannot say that the findings are conclusive. As such, it should only be considered as preliminary, for it merely provides some evidence that a definitive exploration of accident causation as related to the visual environment should be undertaken. However, with respect to the results described above, several judgments regarding the structure of the driver's visual field may be offered:

> The structure of the driver's visual field seems to have a meaningful impact upon accident causation.
>
> The present zoning setback restrictions relating to urban arterial streets seem to have no relationship to the motorist's visual requirements.
>
> Areas containing contiguous buildings with a constant minimum setback distance seem to encourage distractive accidents.

The probable relationship between accidents and building setback may lie in the three visual functions of the driving task. Recall that the driver uses the visual surroundings for three purposes--orientation, destination-location, and curiosity. The nature of a consistent setback relationship is such that it could conceivably work against these functions, for it might confound orientation, confuse destination-location and reduce curiosity. This relationship between the nature of building setback and the visual functions of the driver has not been investigated in detail; however, it appears that the buildings surrounding the road should be located in such a way that they play a consistent role in the driver's perceptual use of the environment. Furthermore, this role should operate within a similar sensory context. That is, the juxtaposition of areas of maximum sense-data next to areas of minimum sense-data should be avoided. It seems that there should be a "middle ground" between visual chaos and visual monotony that fits the driver's perceptual needs and that all variations of environmental structure should occur within this limited spectrum.

Some Generalized Principles of Building Placement

Although a full range of principles related to the design and structure of the driver's environment cannot be delineated until this investigation is expanded and refined, it is possible to state several broad generalizations, emanating from the present investigation, as basic principles of driver-related design. As the effect of the environmental character variables (e.g., signs, visual organization, etc.) have not been verified, the only principles to be derived from the present study are those relating to the effects of environmental structure. These are necessarily few in number and general in character, owing to the need for further research to determine and fully evaluate the nature of the relationship between the physical environment and the motorist. Such principles can be stated as follows:

1. The design of the motorist's environment should be based on the speed and intensity of traffic. As speed increases, building setback should increase. As traffic intensity increases, the perceptual complexity of building forms should be simplified.

2. The design of the motorist's visual environment should exhibit a smooth continuous succession of modulating spaces. The intensity of such modulation should decrease as speed of traffic increases.

3. The design of the motorist's visual environment should exhibit a visual field that expands equally on both sides of the road.

4. The design of the motorist's visual environment should consist of areas of differing perceptual complexity. However, areas of high and low complexity should not be juxtaposed in a discrete fashion, but should be related through a continuous transition of high to low sensory stimulation.

5. The design of the motorist's visual environment must exhibit a sensory rhythm that will allow him to carry out his visual and perceptual task in consonance with his performance of the operational needs of the driving task.

Elements of these principles are illustrated in Figure 4 where a hypothetical driver-related street plan has been contrasted to the present-day pattern of physical development. It should be noted that the vague generality of this illustration is due to the nature of the study findings. The principles delineated above, and illustrated in Figure 4, are meant to exhibit the directions in which the planning and design of urban streets might take to relate the visual environment to the motorist. Application of these principles should enhance the safety, orientation, pleasure, and understanding of the motorist as he moves through urban streets. Through the employment of such principles, as well as others, our visual environment may not only become more ordered but more visible.

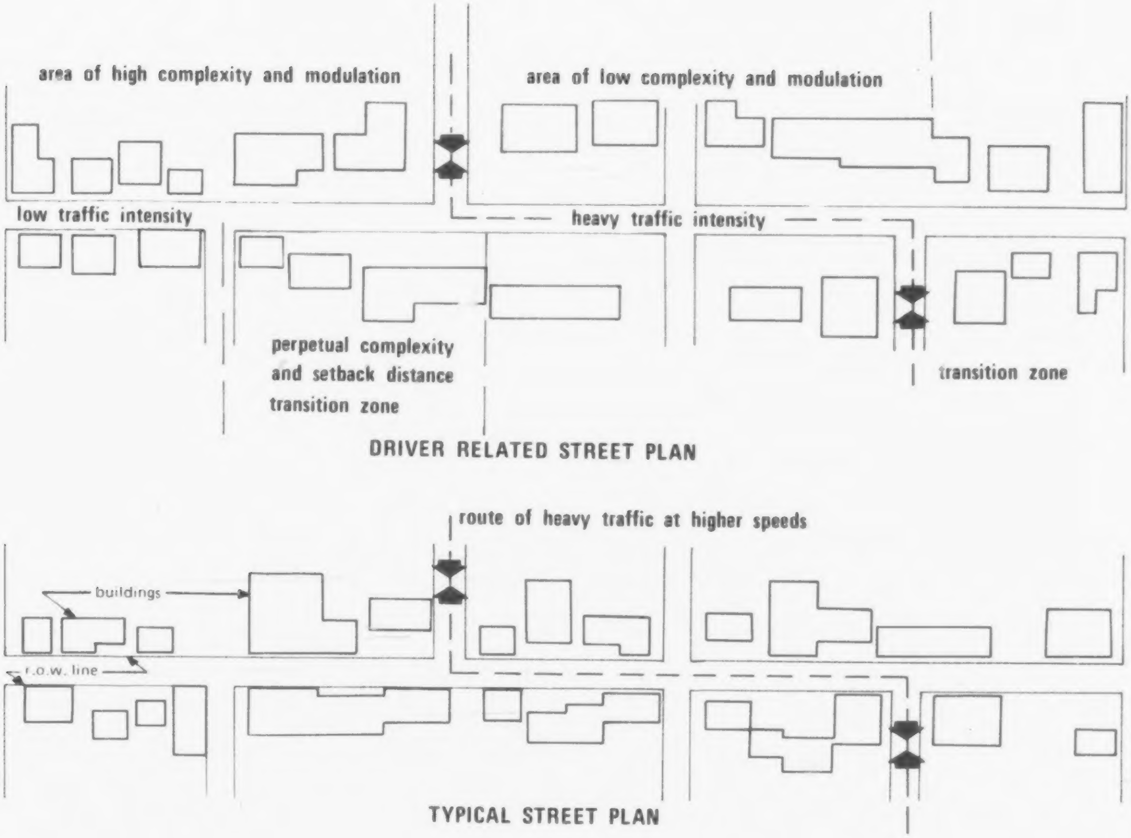

area of high complexity and modulation
area of low complexity and modulation
low traffic intensity
heavy traffic intensity
perpetual complexity and setback distance transition zone
transition zone
DRIVER RELATED STREET PLAN
route of heavy traffic at higher speeds
buildings
r.o.w. line
TYPICAL STREET PLAN

FIGURE 4

PRINCIPLES OF BUILDING PLACEMENT

NOTES

(1) A landmark study in this area is Donald Appleyard, Kevin Lynch and John Myer, The View From the Road, (Cambridge, Mass.: M.I.T. Press, 1964).

(2) There are several studies which have investigated the relationship between roadside development and traffic movement. However, they are only indirectly related to the impact of the visual environment on the motorist. Significant among these are: J. Cark McMonagle, "Traffic Accidents and Roadside Factors," Highway Research Bulletin 55, (1952), pp. 29-41: J.A. Head, "Predicting Traffic Accidents from Roadway Elements on Urban Extensions of State Highways," Highway Research Bulletin 208, (1958), pp. 45-63; and R.M. Michaels and L.W. Cozan, "Perceptual and Field Factors Causing Lateral Displacements," Highway Research Record 25, (1963), pp. 1-13.

(3) Such findings are not the result of any single investigation. Among those studies which deal with elements of this research are: Laurence E. Schlesinger and Mirian A. Safran, "Perceptual Analysis of the Driving Task," Highway Research Record 84, (1963), pp. 54-61; Donald A. Gordon, "Perceptual Basis of Vehicular Guidance," Public Roads, (August, 1966), pp. 53-68; and J.R. Hamilton and Louis L. Thurstone, Human Limitations in Automobile Driving, summarized in Christopher Tunnard and Boris Pushkarev, Man Made America: Chaos or Control?, (New Haven: Yale University Press, 1963), pp. 172-174.

(4) Due to the large number of constraints placed upon the selection of areas for analysis, a very small population was available for study. As such, a potential population of 497 areas containing the desired accident types was reduced to a population of 88 areas in which the variables to be held constant were approximately equal. From this population, a sample of 16 locations was selected and subjected to analysis.

(5) For a discussion of the derivation of the driver's visual field as well as for details of the analysis procedure, see Leslie S. Pollock, Driver Distraction as Related to Physical Development Abutting Urban Streets, (Unpublished Master's Thesis, University of Illinois, Urbana, 1968).

(6) The sets selected for evaluation do not directly resemble the combinations of variables specified in each hypothesis, for such direct relationships could not be statistically grouped for analysis. As an alternative, the sets consist of similar types of variables, e.g., setback means. This formulation was required by the nature of the analysis and the derivation of the variables. As an example, consider the variables implied in the first hypotheses--setback means (W) and building modulation (D). As the value for (D) was derived from the value of (W) the resulting correlation between these variables would be spurious since values emanating from each other would be compared. Hence, the variables for this analysis had to emanate from a different source but still be compatible as exemplified by the setback means of the left side of the street (^{W}left) and that on the right (^{W}right).

THE ENVIRONMENTAL QUALITY OF CITY STREETS: THE RESIDENTS' VIEW POINT

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Protests and research about the environmental and social impact of transportation systems have paid most attention to the problems created by new freeways through urban areas. But while these are the more dramatic instances of traffic impacts, the rapid growth of vehicular traffic has swamped residential streets in cities across the United States and in other countries. Traffic on city streets may affect as many, if not more, people than traffic on freeways. In San Francisco, approximately 60 per cent of the city's major streets (those with a daily traffic volume of over 10,000 vehicles) are lined with residences. (1)

Studies of urban streets (such as the current TOPICS program of the Federal Highway Administration) have concentrated almost exclusively on increasing their traffic capacity, through devices such as street-widening, signalization, and one-way streets, with no parallel accounting of the environmental and social costs of these alternatives. Wilfred Owen (1969) recently directed attention to the role that city streets play in the environmental quality of cities as "the main corridors and front parlors" of the city, but even he did not point out that people also have to live along city streets. To our knowledge, the only empirical studies of life on city streets, apart from some studies of traffic noise and a Michigan study of the economic and environmental effects of one-way streets (Michigan 1969), have been those carried out in Britain since the Buchanan Report (H.M.S.O., 1963 and Chu, 1971). (2)

The investigation reported here is a small-scale attempt to identify the environmental concerns of those who live on city streets in San Francisco. It is a pilot study using observation and open response interview techniques, and does not pretend to statistical significance. The results however are suggestive. The project grew out of the San Francisco City Planning Department's concern over increasing traffic on the city's streets and the side effects of street widenings and other proposed changes in the street system. It was one of a series of studies of environmental conditions made in San Francisco during 1969 and 1970 (San Francisco City Planning Department, 1970).

Study Streets

Of the street blocks selected for a general study of street living, three streets are reported upon here to serve as a model of the research approach and because they contrast the effects of traffic on similar types of streets. The street blocks chosen were adjacent north-south residential streets in the northern part of the city.

Traffic

The major environmental differences between the streets were their traffic levels. The first street, which we shall call HEAVY STREET, was a one-way street with synchronized stop lights and a peak hour traffic volume (at the evening rush hour) of 900 vehicles per hour (average 15,750 vehicles over 24 hours). The second street, MODERATE STREET, was a two-way street with a peak traffic flow of 550 vehicles per hour (average 8,700 vehicles over 24 hours); the third street, LIGHT STREET, had a volume of only 200 vehicles at peak hour (average 2,000 vehicles over 24 hours). (3)

Speeds on all streets could rise to 45 mph or more but only on HEAVY STREET was the speed controlled by the synchronized lights. Traffic volumes had increased on HEAVY and MODERATE STREETS ten years earlier when they were connected to a freeway at their southern terminal. Through traffic was dominant on MODERATE and HEAVY STREETS, and traffic composition included more trucks and buses on HEAVY STREET than on the others.

Population

The three study blocks were part of a residual Italian neighborhood that included other white residents and a small but growing Oriental minority. By social class, education, and income the streets were relatively homogeneous. Contrasts, however, occurred in age, family composition, ownership, and length of residence.

LIGHT STREET was predominantly a family street with many children. Grownup children were even returning to bring up their own children there. One-half of the people interviewed were home-owners, and the average length of residence was 16.3 years. HEAVY STREET, at the other extreme, had almost no children on its block. It was inhabited mostly by single persons of all ages from 20 years upward, with many old people, especially single elderly women. The average length of residence on HEAVY STREET was 8.0 years, and people were nearly all renters. Rents were also somewhat higher on HEAVY STREET, averaging $140 a month among our respondents, whereas those on LIGHT STREET averaged $103. MODERATE STREET stood in between. Average length of residence here was 9.2 years and the average rent was $120.

TABLE 1. STREET PROFILES

Street Characteristics:	HEAVY STREET	MODERATE STREET	LIGHT STREET
Peak hour traffic flow (vehicles/hour)	900	550	200
Average daily traffic flow (vehicles)	15,750	8,700	2,000
Traffic flow direction	one-way	two-way	two-way
Vehicle speed range (m.p.h.)	30-50	10-45	10-35
Noise levels (percentage of time above 65 decibels at the sidewalk)	45%	25%	5%
Accidents (per annum over a 4 block length)	17	12	--
Land Uses	Residential (apartment blocks, apartments)	Residential (apartment blocks, apartments, single family homes) Corner store	Residential (apartments, single family homes) Corner store, Small business
Street width (feet)	69	69	69
Pavement width (feet)	52	41	39
Sidewalk width (feet)	8.5	14	15
Average building height (no. of storeys)	3.5	3.0	2.5
Interview Sample:	HEAVY STREET	MODERATE STREET	LIGHT STREET
Mean household size (no. of people)	1.5	2.6	2.7
Percentage renters	92%	67%	50%
Mean household income ($1,000's)	6.6	8.1	10.0
Mean income/member of household	4.4	3.1	3.7
Mean number of school years completed	14	13	15
Mean length of residence (years)	8.0	9.2	16.3
Mean rents ($ per month)	140.00	120.00	103.00

Source: Traffic statistics and accident counts were obtained from the San Francisco Department of Public Works, Traffic Engineering Section. All other information came from interviews, summer 1969.

Environment

The three streets were typical San Francisco streets with terrace houses or apartments built up to the building-line, very few frontyards and very few gaps between the houses. The architectural style ranged from Victorian to modern. The buildings were finished in either wood, stucco, or brick and were of white or light colors. They were pleasant-looking blocks. The streets were each fairly level, with a slight gradient to the south. They were close to various shopping and community facilities.

Study Design

Two sources of information were used in the study. Detailed interviews lasting about an hour were held with twelve residents on each block, composed of three equal age categories: the young (under 25), the middle-aged (25-55), and the elderly (over 55). This was not a very large sample but since they represented about 30 percent of the households on each block, their attitudes were probably representative of those on the three blocks. Second, systematic observations and, where possible, objective measurements of pedestrian and traffic activity on the streets were carried out.

The study design stemmed from earlier papers by Appleyard and others (Appleyard and Lynch, 1967; Appleyard and Okamoto, 1968) which proposed environmental criteria to be used in transportation system design. The criteria identified in the earlier studies were hypothetical in nature and for this investigation were slightly modified to cover the probable concerns of those living on urban streets. Five major criteria categories were employed to describe the character and day to day use of the street and the concerns and satisfactions of the residents. The interview was introduced as a survey of what the resident thought of his street, inviting suggestions for its improvement. The residents were not told that we were primarily interested in the effects of traffic. The criteria categories were:

Traffic Hazard: concerns for safety in the street associated with traffic activity.

Stress, Noise and Pollution: dissatisfaction with noise, vibration, fumes, dust, and feelings of anxiety concerning traffic.

Social Interaction: the degree to which residents had friends and acquaintances on the block, and the degree to which the street was a community.

Privacy and Home Territory: the residents' responses to intrusion from outside their homes, and the extent of thier sensed personal territory or turf.

Environmental Awareness: the degree to which the respondents were aware of their physical surroundings and were concerned for the external appearance of the buildings and the street.

Each question in the interview was related to one of the above categories, though some answers had relevance to more than one. The answers were independently rated on a five point scale as "environmental quality" ratings by the interviewer and another member of the study team according to a general description of each criterion. Disparate judgments were discussed and a consensus rating was eventually recorded. No attempt was made to weight the responses in terms of their overall importance to the residents although this report emphasizes the main points of concern for the residents as expressed in the interviews. To make these findings more understandable we have graphed the responses in cartoon form and have quoted extensively from the interviews at the beginning of each section.

So far, a public report on the study has met with considerable response in San Francisco. The general concerns of the study, and many of the individual conclusions, have been featured in the local press and on television. Furthermore the officially adopted San Francisco Urban Design Plan (San Francisco City Planning Department, 1971) incorporates many of the recommendations for limiting through traffic on residential streets and creating "protected residential areas."

Traffic Hazard (Figure 1)

Accident counts were equally high on HEAVY and MODERATE STREETS (means of 17 and 21 accidents per year over a four block length).

The danger of traffic was of concern to inhabitants on all three streets, but especially so on HEAVY STREET. These findings are not surprising, since the need for "safe intersections" was the most repeated concern in a concurrent citywide survey of city residents (Kaplan et al., 1969).

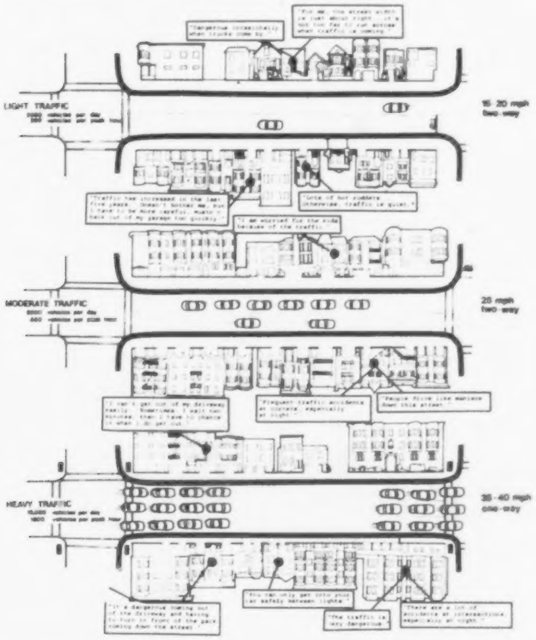


Figure 1. TRAFFIC HAZARD

HEAVY STREET is a one-way street with synchronized stoplights which enable bunches of vehicles, already with momentum from traveling downhill, to travel through at speeds of up to 50 m.p.h. The fast speeds were frequently mentioned in the responses. The very heavy traffic volumes on HEAVY STREET made it unsafe for children, and even for people washing their cars. For residents trying to manoeuver out of their garages, a one-way street has advantages over a two-way street, since the driver has to look one way, but getting a car into a garage can be more difficult since the driver either has to swing across the traffic flow or pull to one side and wait for a lull. Excessive speed was the cause of most of the perceived traffic safety problems, especially on HEAVY STREET. Residents seeing a large number of cars speeding down the hill would wait for someone to make a false move or would listen for a screeching of brakes. Several residents wanted the speed limit on HEAVY STREET reduced.

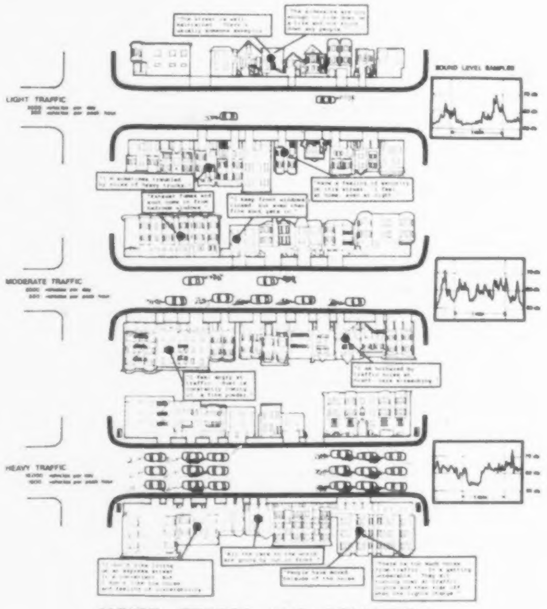
LIGHT STREET, with only a small amount of through traffic, had problems of a different nature. It tended to attract the occasional hotrodder who was, in some instances, a greater menace than the steady stream of traffic on HEAVY STREET. He appeared without warning, often jumping the stop signs at intersections, and was extremely dangerous for children playing in the street. Another problem on LIGHT STREET was the temptation to park where it was immediately convenient. Delivery trucks often parked on the corner when making deliveries to the grocery and blocked the view down the cross street for motorists approaching the intersection.

Residents of MODERATE STREET perceived less safety problems arising from traffic than did the residents of HEAVY STREET. However, they were concerned about traffic dangers. As one respondent put it, "There have been some accidents and I am taking precautions."

Apart from the direct effects of traffic on the feelings of safety, there were some indirect effects. The continuous presence of strangers on HEAVY STREET, even though they were in automobiles, evinced some feelings of fear. One young housewife had frequently been "hassled" from passing cars, and some of the older ladies on HEAVY STREET were "afraid to stop and chat."

As can be seen from the aggregated ratings, there was a consistent trend through all age groups to consider LIGHT STREET as being safe, MODERATE STREET as being neither safe nor unsafe, and HEAVY STREET as being unsafe.

Stress, Noise, and Pollution (Figure 2)



NOISE, STRESS AND POLLUTION

Figure 2.

Measurements of noise levels were made on all three streets. The sound levels were determined through the use of Sound Survey Meters, utilized at four periods during a weekday: early morning (6:30 to 8:30 a.m.), late morning (11:00 a.m. to 12:30 p.m.), late afternoon (5:00 to 6:00 p.m.), and early evening (7:00 to 8:00 p.m.). In each measurement period, fifty consecutive measurements were made at 15 second intervals at corner and midblock locations on each street. To translate these measurements into a useful measure of average conditions, the percentages of time that the noise exceeded certain A-weighted decibel levels [dB(A)] were calculated. From these we computed a Traffic Noise Index,(4) a recognized measure of noise problems, which can be used to predict probable dissatisfaction due to noise. (Griffiths and Langdon, 1967).

On HEAVY STREET, noise levels were above 65 decibels 45 percent of the time and did not fall below 55 decibels more than 10 percent of the time except in the early morning. These noise levels were so high that the Traffic Noise Index read right off the scale. The two-minute sample sound level recording in Figure 2 illustrates the uneven character of noise due to the waves of cars that flowed down the street, and to the occasional noisy vehicle which exceeded 70 decibels.

On MODERATE STREET, sound levels were above 65 decibels for 25 percent of the time. By the Traffic Noise Index, the noise level (6.5) would be rated as "definitely unsatisfactory." On LIGHT STREET, the quietest of the three, sound levels rose above 65 decibels only 5 percent of the time, meaning that one half of the residents would consider the noise level "unsatisfactory" and one half "satisfactory." The two-minute sample sound level recordings on MODERATE STREET show that the noise levels tended to be more variable than on HEAVY STREET but in the same range, whereas the sound level chart on LIGHT STREET shows an ambient noise level much lower than the other two streets.

After the danger of traffic itself, traffic noise, vibrations, fumes, soot and trash were considered to be the most stressful aspects of the environment on these three streets. On HEAVY STREET, the noise was so severe that one elderly couple was forced to try to catch up on sleep in the daytime. Many, especially the older people, were unable to be objective about the other characteristics of their street because these stresses totally colored their perceptions of their environment. Adjectives such as "unbearable," or "too much" or "vulnerable" were typical of the responses.

As with traffic hazard, the large mass of vehicles was not always the major problem. It was often the lone individual or the unusual vehicle type that disturbed the situation. This was certainly true of HEAVY STREET where the large majority of cars were reasonably quiet and passed by at a smooth even flow. The real offenders were sports cars, buses, and trucks. The steady drone of traffic was certainly bad, but the random deep-throated roar of a bus or large truck, with the accompanying shudder that rattled every window, unnerved the most hardened resident, especially when it continued day and night. The screeching of brakes at the intersections added to their distress.

Residents on HEAVY STREET had petitioned for a sign prohibiting trucks and buses. The sign was installed, but it did not mention buses. It was small, the same color as the background, and was seldom seen. In any case, the law was not enforced, so truck drivers had learned to continue on their way with impunity. Noise problems were not so acute on MODERATE STREET, where people were more bothered by the fumes, dust, and soot which penetrated into their living rooms and bedrooms. LIGHT STREET had a few complaints of occasional noise.

Other Forms of Pollution

The condition and cleanliness of the buildings on the three streets was generally high. Maintenance and clean appearance were clearly important to all the inhabitants. HEAVY STREET was constantly on show to outsiders who were traveling through it, and the owners of the buildings were careful to maintain a high standard of cleanliness despite the "disgusting amount of litter." The appearance of a quality environment was therefore maintained -- and paid for through higher rents -- but because the street did not encourage people to be outgoing, tenants were reluctant to accept responsibility for the street itself. Therefore they avoided picking up trash and were slow to defend the street against vandalism and abuse.

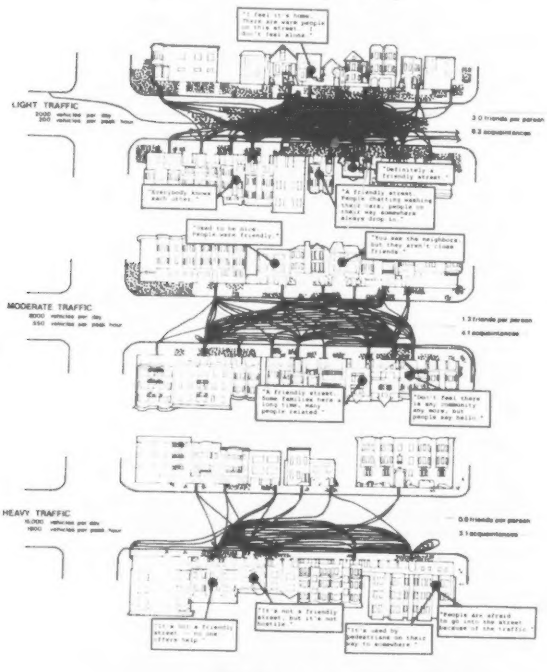
On MODERATE STREET, concerns for trash, dust, and soot, where specifically referred to, were more pronounced than on HEAVY STREET. This street was going through a difficult stage. Traffic and traffic problems were increasing, and there was no clear demarcation between public territory, which was the responsibility of the city, and local territory, which might have been the responsibility of the residents. People in parked cars had been observed dumping the contents of ash trays and beer cans into the gutter. Even so, it was still seen as a "good respectable place to live" and sidewalk maintenance by the local inhabitants helped to keep up the appearance of the street.

LIGHT STREET was very seldom seen by outsiders and so the issue of maintenance was a local matter. This street was also seen to be changing and residents had noticed signs of deterioration. As one resident put it, "The quality of [LIGHT STREET] is getting better in that people take great care of their properties, but worse in that there is more traffic and more cars on the street." Indeed, the responses showed that many inhabitants took an interest in looking after the cleanliness of the street, and some had planted their own trees.

The only other inconvenience mentioned was the crowdedness of parking conditions. Many suburban commuters and users of the nearby shopping center were parking on all three streets and taking up parking spaces of the residents. In response to questions concerning the adequacy of street lighting, garbage collection, and street cleaning, respondents considered the three streets to be without serious problems.

In reaction to all these issues, each age group found HEAVY STREET more severe, and the old and middle-aged groups found MODERATE STREET worse than LIGHT STREET. The only exceptions were residents under twenty-five, who were more critical of LIGHT STREET. People on LIGHT STREET tended in many cases to be more aware and more critical of their street, while those on MODERATE STREET were more apathetic.

Social Interaction (Figure 3)


"I feel it's home. There are warm people on this street. I don't feel alone."
LIGHT TRAFFIC
2000 vehicles per day
200 vehicles per peak hour
3.0 friends per person
6.3 acquaintances
"Definitely a friendly street."
"Everybody knows each other."
"A friendly street. People chatting washing their cars, people on their way somewhere always drop in."
"Used to be nice. People were friendly."
"You see the neighbors but they aren't close friends."
MODERATE TRAFFIC
8000 vehicles per day
550 vehicles per peak hour
1.3 friends per person
4.1 acquaintances
"A friendly street. Some families here a long time, many people related."
"Don't feel there is any community any more, but people say hello."
HEAVY TRAFFIC
16,000 vehicles per day
1900 vehicles per peak hour
0.9 friends per person
3.1 acquaintances
"It's not a friendly street -- no one offers help."
"It's not a friendly street, but it's not hostile."
"It's used by pedestrians on their way to somewhere."
"People are afraid to go into the street because of the traffic."

SOCIAL INTERACTION

LINES SHOW WHERE PEOPLE SAID THEY HAD FRIENDS OR ACQUAINTANCES
DOTS SHOW WHERE PEOPLE ARE SAID TO GATHER

Figure 3.

Residents were asked a series of questions about the friendliness of the street, the numbers of friends and acquaintances they possessed, and the places where people met. Each respondent was shown a photograph of the buildings on the street and asked to point out where any friends, relatives, or acquaintances lived.

On LIGHT STREET, inhabitants were found to have three times as many friends and twice as many acquaintances on the street itself (9.3 friends and acquaintances per person) as those on HEAVY STREET (4.2 per person). The diagrammatic network of social contacts in Figure 3 shows clearly that contact across the street was much less frequent on HEAVY STREET than on LIGHT STREET. The friendliness on LIGHT STREET was no doubt related to the small amount of traffic, but also to the larger number of children on the street and the longer length of residence of the inhabitants. The statements of the inhabitants corroborate this.

On HEAVY STREET, there was very little social interaction. With few if any friends (0.9 per respondent) the residents did not consider it a friendly street. Although it might be argued that this was primarily a consequence of the life style of those living on HEAVY STREET (Keller, 1969), the sense of loneliness came out very clearly, especially in the responses of the elderly. As for MODERATE STREET, residents felt that the old community was on the point of extinction. "It used to be friendly; what was outside has now withdrawn into the buildings. People are preoccupied with their own lives." Some of the families had been there a long time, but the number of longtime residents was diminishing. As other respondents put it, "It is a half-way from here to there," "An in-between street with no real sense of community." There was still a core of original Italian residents lamenting that "There are no longer any friends around here." The average number of friends and acquaintances per respondent was only a little higher (total 5.4 per person) than on HEAVY STREET.

There were sharp differences between age groups. The middle-aged residents on the three streets possessed a similar number of friends,although those on LIGHT STREET had more acquaintances. This age group was probably more mobile and better equipped to make friends than the other groups. The young and old, on the other hand, who had many less social contacts on HEAVY STREET than on LIGHT STREET, appeared to be more affected by the amount of traffic, especially in establishing casual acquaintanceship with neighbors in the street.

From the notations of street activities drawn by the subjects on the map of the streets (Figure 3), it can be seen that LIGHT STREET had the heaviest use, mostly be teenagers and children. MODERATE STREET had lighter use, more by adults than by children, and HEAVY STREET had little or no use, even by adults. The few reported activities on HEAVY STREET consisted of middle-aged and elderly people walking on the sidewalks but seldom stopping to pass the time of day with a neighbor or friend. Reports on MODERATE STREET indicated that the sidewalks were more heavily used by adults, especially by a group of old men who frequently gathered outside the corner store. Children and some teenagers played on the sidewalks, mostly on the eastern side of the street,(probably because most of their homes were on the eastern side and they didn't like to cross the road except at the crossings). On LIGHT STREET, people used the sidewalks more than any other part of the street, but children and teenagers often played games in the middle of the street. Children often used the sidewalks extensively because of their gentle gradient and their width. Again, a corner store acted as a magnet for middle-aged and elderly people, and a tennis store across the road attracted a small group of young adults. Front proches and steps on LIGHT STREET and to a certain extent on MODERATE STREET were used for sitting, chatting with friends, and, by children, for play. The residents of HEAVY STREET regretted their lack of porches.

In conclusion, there was a marked difference in the way these three streets were seen and used, especially by the young and elderly. On the one hand, LIGHT STREET was a lively close-knit community whose residents made full use of their street. The street had been divided into different use zones by the residents. Front steps were used for sitting and chatting, sidewalks by children for playing, and by adults for standing and passing the time of day (especially around the corner store), and the roadway by children and teenagers for playing more active games like football. However, the street was seen as a whole and no part was out of bounds. This full use of the street was paralleled by an acute awareness of the physical environment (as will be described in the section on environmental awareness).

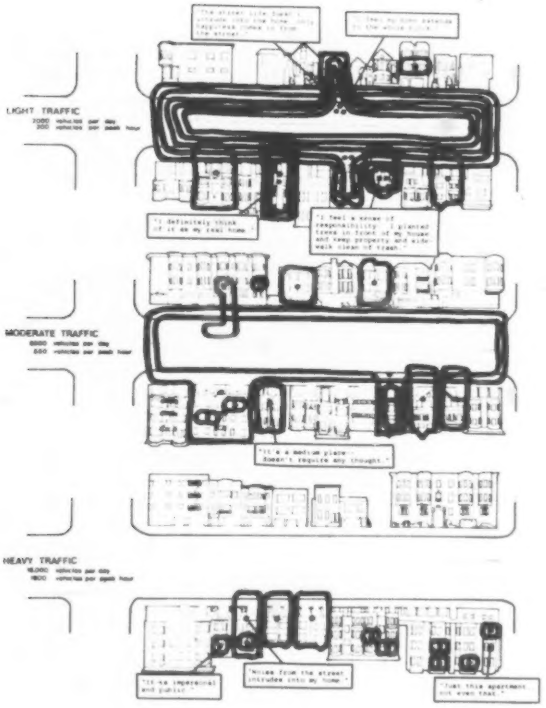
HEAVY STREET, on the other hand, had little or no sidewalk activity and was used solely as a corridor between the sanctuary of individual homes and the outside world. Residents kept very much to themselves so that there was no feeling of community at all, and they failed to notice and remember the detailed physical environment around them. MODERATE STREET again seemed to fall somewhere between the two extremes. It was still quite an active social street, although there was no strong feeling of community. Most activity was confined to the sidewalks, where a finely sensed boundary separated pedestrians from traffic.

Privacy and Home Territory (Figure 4)
A number of questions were asked to gauge whether inhabitants felt they had sufficient privacy, and whether they had any feelings of stewardship over their streets.

In their responses, residents of LIGHT and MODERATE STREETS, especially middle-aged residents evidenced great pride in their homes and streets. On HEAVY STREET there was little peace and seclusion, even within the home, and residents struggled to retain some feeling of personal identity in their surroundings.

Perception of individual privacy was high throughout this area, perhaps because of the feeling of "privacy and seclusion that exists in any middle class area," as one respondent put it. Inevitably, in a tightknit community like one that existed on LIGHT STREET, life on the street tended to intrude more into a person's home than it would on a less friendly street, but the residents had achieved a good balance wherein they maintained their own household privacy and yet contributed to the sense of community. As one woman enthusiastically put it, "Only happiness enters in." Children and young people often preferred the lack of seclusion because they liked to be part of things. On LIGHT STREET a satisfactory balance had been achieved between a feeling of privacy and contact with the outside world. Even on HEAVY STREET residents occasionally enjoyed the street activity. ("I feel it's alive, busy, and invigorating.") However, for the majority, the constant noise and vibration were a persistent intrusion into the home and ruined any feeling of peace and solitude.

Figure 4 deals with the residents' conceptions of personal territory. Even though legally a householder's responsibilities extend to the maintenance of the sidewalk immediately outside his building, residents on MODERATE and LIGHT STREETS considered part or all of the street as their territory. However, the HEAVY STREET resident's sense of personal territory did not extend into the street, and for some, mostly renters in the large apartment blocks, it was confined to thier own apartment and no further. This pattern of territorial space corresponds to the pattern of social use of each street. The contrast between the territorial restrictions of those living on HEAVY STREET and the territorial expansiveness of those on LIGHT STREET is one of the more salient findings of the study. The residents on LIGHT STREET are quite similar in this respect to those West End Italians in Boston who considered the boundaries between house and street space to be quite permeable (Fried and Gleicher, 1961). In sum, HEAVY STREET was seen as considerably less private than the other two streets, especially for those most confined to the street, the young and the old.


"I definitely think of it as my real home."
"I feel a sense of responsibility. I planted trees in front of my house and keep property and sidewalk clean of trash."
LIGHT TRAFFIC
MODERATE TRAFFIC
"It's a medium place-- doesn't require any thought."
HEAVY TRAFFIC
"It's impersonal and public."
"Noise from the street intrudes into my home."
"Just this apartment, not even that."

HOME TERRITORY

LINES SHOW AREAS PEOPLE INDICATED AS THEIR "HOME TERRITORY"

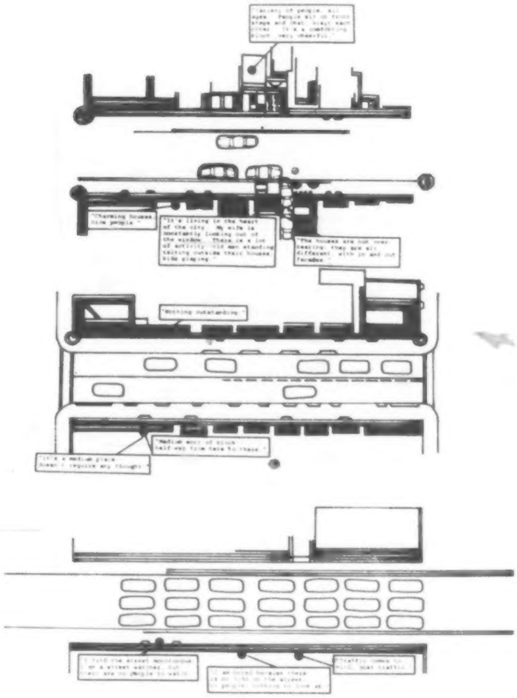
Figure 4.

Environmental Awareness (Figure 5)

Street dwellers were each asked to recall all important features of their streets, to judge whether their street was in any way different from surrounding streets, and to draw a map of their street.

Figure 5 is a composite of all the maps that each person drew for his own street. The responses to the questions were much richer in content -- and more critical in character -- on LIGHT STREET than on the other two streets. This can be partly explained by the greater differentiation of frontyards and smaller houses, but it clearly stemmed from an increased awareness of the street environment by the residents themselves.

Interest in the street as evidenced by the maps drawn varied by age group. LIGHT STREET had tremendous appeal for children, who recalled individual buildings, front yards, steps, particular parked cars, manhole covers, telegraph poles, and even the brickwork setting around the base of a tree. Many of these detailed elements were obviously encountered during their play on the street. On MODERATE STREET, where there was less street activity, the maps of children and young people were accordingly less rich.


"Charming houses, nice people."
"Nothing outstanding."
"It's a medium place-- doesn't require any thought."

ENVIRONMENTAL AWARENESS

COMPOSITE OF MAPS PEOPLE DREW OF THEIR STREETS

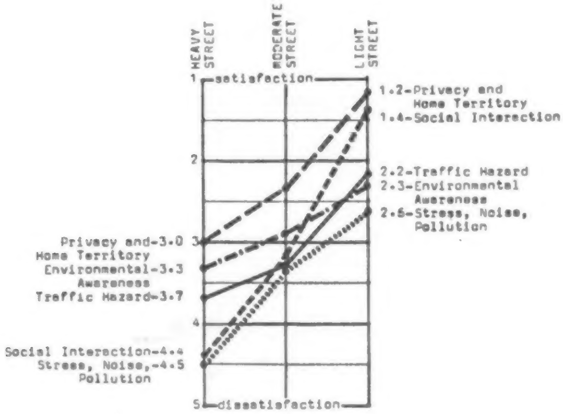
LINES INDICATE NUMBER OF TIMES FEATURE WAS DRAWN BY RESIDENTS

Figure 5.

Middle-aged people on the other hand seemed to have a more complete impression of their street. Their recollections included combinations of buildings, sidewalks, the roadway, and the traffic itself. For them, LIGHT STREET was seen as a collection of individual buildings with differences in front yards and porches. MODERATE STREET was much more straight-walled. Residents had accurate memories of driveways, pedestrian crossings and road markings (possibly because it was seen as a traffic route with finely defined boundaries).

HEAVY STREET was seen overwhelmingly as a continuous traffic corridor, straight-sided without a break for cross streets and packed with cars. The traffic itself was an easily identified characteristic of the busier street.

As for the responsiveness of the street environment to the needs of the street dwellers, LIGHT STREET once more showed up well. Two trees had been planted in the sidewalk, other plants were thriving in the occasional frontyard, and flower boxes were prevalent. On HEAVY STREET, the sidewalks were too narrow to allow anything to grow except the very small bushes that flanked the doors of one or two apartment buildings.



ENVIRONMENTAL SATISFACTION

Figure 6.

Discussion of Conclusions

Objective observations of environmental quality, through traffic flow and noise counts, showed that environmental conditions on HEAVY STREET were particularly severe. Though complaints were numerous, however, they were not so strong as one might reasonably expect. There had been very little public complaint or protest by any group. Why was this?

One major reason appears to be that the erosion of environmental quality had been subtle and slow, taking place over a period of ten years or more. During this time the workings of environmental selection and environmental adaptation had been allowed to operate. These are important phenomena to consider in measurements of response to environmental quality.

1. The workings of environmental selection may be stated as follows: an environment tends to be selected by those groups who find it most amenable, and to be rejected by those who find it least amenable. Hence when traffic increased on HEAVY STREET, families with children moved away, and single people and couples whose local environmental needs were less but who valued accessibility tended to replace them. The principle does not work perfectly however. Those who are unable to select their preferred environment through lack of financial, informational, or psychological resources become "locked in" to certain environments, and are therefore likely to suffer the most from changing environmental quality. On HEAVY STREET the older people, finding it too costly and too much effort to move, experienced severe discomforts, and the families who had to remain on MODERATE STREET experienced the loss of friends. Similar predicaments face lower income populations.

People may select a less than ideal environment for reasons other than lack of resources. Many make a compromise, sacrificing amenity for the benefits of, for example, an easily available apartment or accessibility to other parts of the city. The apartments on LIGHT STREET had less turnover so they were seldom on the market. Others make errors of judgment. Visually HEAVY STREET is a well-maintained high quality street. Therefore an apartment hunter might be deceived. Another kind of error is the inability to predict future deterioration. When many of the present inhabitants moved in to HEAVY and MODERATE STREETS conditions were good. Since then they have worsened.

2. By environmental adaptation we mean that those who remain in one environment for a length of time will become adapted (or resigned) to it whether or not it is or has been pleasant, especially if they see no future change in sight. Evidence for this phenomenon can be found in this study, especially in some of the more indifferent responses on HEAVY STREET. (Such evidence can also be found in the research literature in this field [Sonnenfeld, 1966; Wohlwill, 1968].) Those with low expectations or aspirations may be content with any environment.

Besides private adaptation, there appears to be a more publicly oriented defensive kind of adaptation. Most people are stuck with the choices they have made. When an interviewer arrives at the door and asks if there is anything they dislike about their environment, people may not wish to complain even though they may privately acknowledge that their environment is unsatisfactory. They may refuse to complain in order to keep up their social image and the sales value of their property, or through reluctance to admit that they have limited resources or have made an error of judgment.

Individual and family adjustments to a deteriorating environment were further muted because there was no clear public target for resentment, only the individual automobiles and trucks. No particular agency was threatening the environment or initiating changes. This worked both ways; residents' hopes were not raised that anything would be done about their problem, but neither were their frustrations focused sufficiently for them to band together in protest.

Despite the private nature of the adjustments and the slowness of the deterioration, a majority of the inhabitants were still well aware of their plight, as their comments tell.

One final and more positive finding of this study was what it told us of life on a "good" residential street, namely LIGHT STREET. Since we cannot hope to improve urban environments without some positive goals to work towards, LIGHT STREET performs a critical function.

Environmental Standards

Environmental conditions on residential streets will not be improved unless means of determining acceptable and unacceptable conditions are available. Present planning thought is running against the formulation of standards, as planners have come to realize the variability of population needs and situations and the difficulties of scaling environmental conditions. Yet without standards or specific guidelines, planning controls will remain amorphous and ineffectual. There is an urgent need at the very least to articulate unacceptable environmental conditions for particular groups. These conditions might be couched in the form of *environmental performance standards*.

The field of noise abatement, which has progressed quite far in trying to set environmental standards related to behavioral response, has encountered some difficulties. Simple decibel ratings (for example, 45 decibels as a tolerable level inside residences) have to be modified by the "duration, frequency, substantive content of the sound and individual differences" (H.U.D., 1969). The Traffic Noise Index (Griffiths and Langdon, 1968) developed in Britain attempts to take a few of these factors into account. The Buchanan Report (H.M.S.O., 1964) identified "vulnerable" populations. But what about standards which will allow people to feel comfortable on sidewalks, or to cross the street, which encourage neighborliness, allow privacy, and an ample sense of personal territory, or which promote care and interest for the physical environment of the street? These are even more difficult measures to scale. The effort to measure pedestrian crossing delay times as an indicator of residential quality, which was used in the *Kensington Environmental Management Study* (Greater London Council, 1966), was an interesting attempt in this direction. The work reported here is not substantial enough to develop such indicators, but this is the direction of our research. (5)

NOTES

1. Estimated from Report No. 4, San Francisco Urban Design Study 1970.
2. For example the Barnsbury Environmental Study (M.O.H.L.G., 1968), and the Pimlico Precinct Study (City of Westminster, 1968).
3. All traffic statistics were obtained from the San Francisco Department of Public Works, Traffic Engineering Section.
4. The Traffic Noise Index is a function of the 50% noise level and the difference between the 10% and 90% levels.

   $$TNI = L_{50} + 4(L_{10} - L_{90}) - 30$$

   This figure has been shown to correlate with expressions of annoyance. Our budget did not allow us to take the customary hourly samplings over the full 24-hour period.
5. A study of a larger residential area in Oakland, California is now under way supported by small grants from the U.S. Department of Transportation and the National Institute of Mental Health.

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5

URBAN PATH-CHOOSING BEHAVIOR: A STUDY OF ENVIRONMENTAL CLUES

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Abstract

This paper describes a study of the path-choosing behavior of auto drivers at a familiar task: That of trying to find and enter a freeway in the city. The study looks at the role of elements of the physical environment as clues, and tests navigational behavior in the presence and absence of selected clues. Results indicate a clear order of importance among clues, and a change in path-choosing behavior in the absence of important clues.

Background

The spatial mobility of individuals in the city is a key element in their ability to "use" the city to best suit their own needs. The social importance of the mobility issue, and the related problem of the accessibility of various urban activities, is well established (1). This paper focuses on a limited aspect of mobility: the process by which individual city users find their way around the spatial environment. Of particular interest are the perceptual and cognitive processes that the individual user brings to bear on the problems of perceiving, understanding, and making choices in the process of getting from where he is to where he wants to go.

Spatial Perception and Learning

Spatial perception and cognition have received substantial treatment in the literature by Bruner (2), Piaget (3), and others. However, work directly relating these processes to the urban spatial environment is at the present time embryonic and methodologically fragmented. Much of the current research in this area centers around cognitive mapping, or "mental maps", and can be traced to E.C. Tolman and his work on spatial learning in rats (4). Work on cognitive mapping, such as that of Blaut and Stea (5), has studied how well, and what, people learn about the spatial environment. Considerable work has been done on imagery and the perceptual structure of the city, much of it stemming from Kevin Lynch's classic book (6). Among others, Appleyard, Lynch and Myer (7), and Carr and Schissler (8), have extended this to study the perceptual structure of the city in terms of sequential experience. This work has contributed to what is now known about the problems of orientation and navigation in the spatial environment and the role that cognitive mapping plays in that process.

Navigating in Unfamiliar Environments

It may be the case, however, that the usefulness of cognitive maps of specific environments is limited as an aid to navigation. This is often the case when the user finds himself in an area of a city with which he is not familiar, and in which he is operating for the first time. Why is this an important problem? First, many cities are expanding in scale. A metropolitan area such as Los Angeles is so huge as to effectively prevent all but the most assiduous students of geography from "knowing the city well." Further, the rate of change is so rapid that familiar neighborhoods, interchanges, and other bits of urban fabric may be completely unrecognizable after a few months or years. And, people often find themselves users of many different cities. Having to be operational in the face of this diversity and number of changing spatial environments poses a formidable learning task in the traditional cognitive mapping sense. Going about this task by trying to "learn" each neighborhood and city seems impractical, and so it may be asked whether individuals are able to navigate successfully in strange cities without having "learned" them, and whether they can do so in a relatively error-free fashion. It could be argued that use of the spatial environment should not be dependent on one's having memorized it, that cities should be clearly legible and self revealing as one moves through them. But cities are often illegible and confusing to unfamiliar users, yet somehow they manage to make their way around them, albeit with many errors and much frustration. It would be interesting to know what strategies and clues are useful for navigation under such adverse conditions as a first step toward understanding whether and what kind of design intervention may be needed.

This paper describes a study of the path-choosing behavior of drivers in just such a situation -in an area of the city with which they are unfamiliar. The study attempts to probe the role of environmental clues in path-choosing behavior in unfamiliar urban settings.

Experimental Design

The objective is to study driver path-choosing behavior under varying conditions of an urban spatial environment. Users in this case are automobile drivers, and the field in which they are operating is a portion of the surface street system in a medium density urban area. The term spatial environment refers to the fixed physical environment visible to the driver: Streets, buildings, signs, trees, etc. Dynamic factors are excluded as the focus is on the role of the fixed spatial environment in user path-choosing behavior.

Hypothesis

Under conditions where the driver is unfamiliar with the specific area of the city through which he is moving, does the absence of key sets of elements (clues) from the fixed spatial environment correlate with significant modification in user path-choosing behavior when compared with behavior in the presence of those environmental elements? The hypothesis states that the successive removal of combinations of 2 classes of environmental elements will result in a significant change in user path-choosing behavior.

The objective is to test certain elements of the spatial environment as possible clues for drivers engaged in a path-choosing task, and to study what search strategies are being utilized by drivers assigned the task of locating and getting on a nearby freeway. The elements being removed are (a) high rise buildings, and (b) freeway structural elements.

The driver is essentially denied the use of his already developed cognitive maps and related skills of orientation and tracking. The term 'already developed cognitive map' refers to a mental map of a specific urban environment, such as 'Westwood Village' or 'Sunset Strip'. If the user can not effectively utilize these skills in finding his way around the city, what search strategies does he then resort to? Is there a relationship between these strategies and elements of the spatial environment being used for information (clues)? This is seen as a beginning attempt at understanding what might be termed a generalized cognitive map, or set of typical, repeatable relationships which individuals expect to encounter in the spatial environment, and use to "predict the environment" in the absence of any specific cognitive map.

This study uses a slide-simulated trip of an automobile driver in which subjects are given the task of moving through a surface street system and finding and accessing a specific freeway, going in a specific direction. He is without benefit of prior knowledge of the specific area of the city through which he is moving (that is, without a specific cognitive map). Finding and getting on freeways is a problem universally experienced by auto drivers in Los Angeles. As such it is a good example of the difficulties often encountered by users in making a transition between two discontinuous environmental systems.

The null hypothesis states that the successive removal of combinations of 2 classes of environmental elements will not result in a significant change in user path-choosing behavior. Behavior is measured by subjects decision to turn or not at 5 consecutive choice points (intersections) as they try to solve this task.

The intent of this experiment then, is to test the role of a limited number of environmental elements as inputs to the driver's path-choosing process.

Environmental Simulation

In designing an experiment to test the hypothesis, the question of whether, and how, to simulate 'the environment' had to be addressed. First, it should be noted that this task involves interaction between individual skills and environmental information, and it is emphasized that individual differences among subjects introduce acknowledged variation. To try to reduce variation in environmental information, it was necessary to find a way to simulate a portion of the real urban environment in a controlled way. Because the nuances of clue relationships are poorly understood, it was reasoned that the simulation should be as close to the real environment as possible. The obvious technique would be some kind of photography, which gives a rich and fairly complete representation. At the other end of the spectrum, a minimal definition technique could have been used, such as line drawings, where one could control the things one put in to the environmental simulator. In the case of the present experiment the need was to selectively control the elements taken out of the environment, since the objective was to study behavior in the absence of only certain elements. Another requirement was to be able to simulate a sequential experience through space. This sequential experience had to have the capability for branching, to allow for subject choice making. Direct use of the real environment as a laboratory was ruled out for two major reasons: First, numerous dynamic variables such as traffic conditions and daylight couldn't be controlled. But more seriously, it is impossible to selectively remove major elements of the fixed environment, such as buildings, bridges, etc. Therefore, some means for simulating a trip through a real environment had to be devised. Several alternatives were explored. First, the use of movies was considered, but rejected. Movie film can fairly accurately reproduce the sensation of motion, of turns and a sense of direction, but branching is difficult to achieve. Its principal drawback is that retouching the frames to remove elements from the picture is incredibly difficult due to the small size and huge number of frames. Video tape has some of the advantages of movies, but lacks color and the high resolution of movies. A satisfactory technique for selectively removing parts of the image could not be found. Additionally, the branching difficulties are at least as severe as those involved with movies.

Computer generated simulation was considered, but the state of the art is such that all the simulation criteria could not be satisfied. For a thorough discussion of the state of the art in computer simulation of three dimensional environments, the reader is referred to a recent Scientific American article by Ivan Sutherland (9).

The use of photographic transparencies (35mm slides) was considered. If taken at close intervals, slides can replicate motion to some degree, although they cannot provide continuous motion like film or video tape. Use of slides does however, reduce the number of frames to a more manageable number than that possible with movie film. Slide sequences can be branched without an appreciable break in the continuity of presentation. Techniques are available by which the photographic images can be altered in fairly great detail, making this adaptable to the need for removal of visual elements from the photos. Simulation by 35mm slides was finally selected and used for this experiment. Some precedent for the use of slide simulation exists in the work of Winkel and Bouterline in a study of visitor experiences at the Seattle World's Fair as well as in the use of retouched photographs by Winkel, Malek, and Thiel in assessing reactions to roadside environments (10). Although this was the best available methodology, it should be noted that it is still relatively primitive, a fact that will be taken into account in analyzing the results.

The role of the driver as a maker of decisions is of prime interest. As drivers in an urban setting, individuals make substantial numbers of choices in rapid-fire succession. Since a major concern of this paper is with navigational decision-making behavior, the experiment had to create an on-line decision task. For this reason the experiment was set up as a decision tree to allow direct observation of subject choice-making behavior.

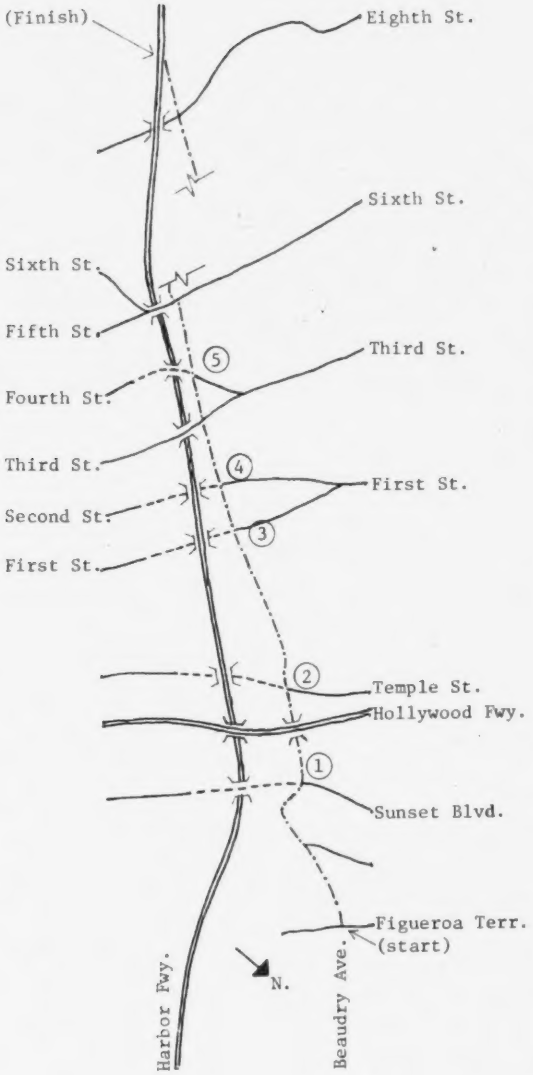
A location was sought in the Los Angeles area in which there were no freeway signs or on-ramps for a considerable distance of surface street near a freeway. Other elements sought included high rise buildings, low to medium density residential and commercial uses, as well as limited views of freeway structure and right-of-way landscaping, and a grid street pattern with cross streets intersecting a freeway. A location was found west of downtown Los Angeles which satisfied these criteria. Beaudry Avenue, from Figueroa Terrace to Eighth Street, paralleling the Harbor Freeway just to the west of the freeway, was chosen as the location to be simulated. Beaudry Avenue is part of a consistent grid pattern of streets in that area, and has a number of streets that cross it at right angles. There are no freeway signs along this length of Beaudry Ave., and there are no freeway on-ramps on the West side of the Harbor Freeway between Figueroa Terrace on the north, to Eighth Street on the South. See Figure 1 for a map of the simulated environment, and sample views at each choice point.

Removal of Clues

Clues are defined in this context as any information received by the user from the visually perceived spatial environment which is used by him in conceptually organizing and operating in that environment. I have hypothesized that two identifiable classes of elements (clues) in the spatial environment can be correlated with spatial path-choosing behavior in the context of a particular task (locating and finding access to a freeway). The strategy adopted was one in which clues would be removed sequentially and additively, in three versions of the same trip, that is, first a control sequence with no clues removed, then remove clue a, then clues a and b.

Constraints on time and resources limited the study to the selection of two classes of environmental elements for study: High rise buildings, and freeway structural elements. High rise buildings in a city such as Los Angeles tend to be very prominent and visible for miles (on a clear day). Their role in helping users to establish and maintain orientation is well documented by Lynch (11). The reason for their selection as a clue here is to see whether individuals treat the presence of high rise structures as having any particular typical relationship to the presence of freeways.

The second class of clues includes the physical freeway structure, including ramps, bridges, and abutments. These elements are proximate clues, in that they are not normally seen at more than short distances. It is suspected that experienced drivers may have a well integrated concept of how the freeway parts relate, allowing them to make fairly accurate assumptions about freeway location, direction, and access, from having sighted only a small piece of the freeway structure.


(Finish)
Eighth St.
Sixth St.
Sixth St.
Fifth St.
⑤
Third St.
Fourth St.
Third St.
④
First St.
Second St.
③
First St.
②
Temple St.
Hollywood Fwy.
①
Sunset Blvd.
Figueroa Terr.
(start)
N.
Harbor Fwy.
Beaudry Ave.

Schematic Map of Simulated Trip

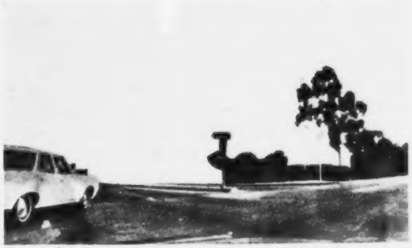
Downtown Los Angeles

Numbers indicate choice points and correspond with numbered photos showing view to left at each choice point.

------ Left Branching Options
-·-·-·- Main Route

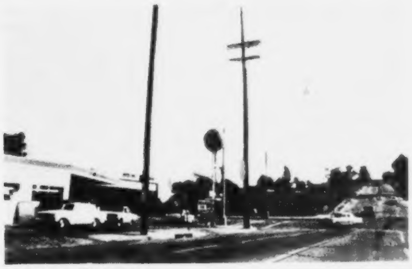
Figure 1.

5



Fourth Street

4



Second Street

3

Thirsty
Try This
Un

First Street

2

Temple Street

1

Sunset Boulevard

A series of photographs was taken at 175 foot intervals along the length of the Beaudry Ave. site. Similarly, the five major streets crossing Beaudry Ave. were photographed from their intersection with Beaudry, to the East, until they had passed over or under the Harbor Freeway. This created in effect a 'tree' with one main stem (Beaudry) and five branches, all to the left.(Figure 1.) Presentation of the slide sequence was done at approximately four second intervals per slide, with the screen 12 feet from the subject and the picture five feet wide.

A second projector was set up to project on a screen to the left of, and perpendicular to, the first screen. Screen #2 displayed the left turn branches of the sequence. Figure 1 contains a sample photo of each choice point. The presentation of the main sequence down Beaudry Ave. was done with the #2 screen darkened, and at each major intersection "the view to the left" was presented with the option to go straight ahead on Beaudry or to "turn left". If the subject opted for the left turn, the branching sequence was presented. When the end of the branching sequence was reached, the subject was told that he had passed the freeway and would have to return to Beaudry Ave. and continue his search from there. If a subject went to the end of a left branching sequence and did not himself say he wished to turn around, and go back to Beaudry Ave., he was asked which way he would go from his present position before being told that he would have to return to Beaudry Ave. Every subject progressed through the entire length of Beaudry Ave., whether or not he made any left turns, until finally reaching the access ramp to the Harbor Freeway at Eighth Street. A slight foreshortening of the actual route to the freeway on-ramp was introduced near the end of the sequence for reasons of increased continuity. (Figure 1.)

All subjects were members of the staff, faculty or students of the School of Architecture and Urban Planning, UCLA. Each of the slide sets was designed for 10 subjects. Information gathered on each subject included the following: Age; Occupation; City in which he has driven most; Length of time in Los Angeles; Total mileage driven last year; Frequency that individual drives an auto; Frequency that individual drives on a freeway.

Table 1 lists the subject characteristics by groups I, II and III. Each subject viewed only one set of slides, and subjects were asked not to discuss their experiences until all the experimenting had been completed. Testing was actually conducted for the first three sets of slides, with N=29.

	Sex	Mean Age	Mean Yrs. in LA	Mean Annual Mileage	Frequency of Freeway Driving	Drive Auto Daily
Group I N=9	4 F 5 M	28.5	9.5	8,450	4:Daily 3:Twice/wk 1:Twice/mo 1:None	8 yes 1 no
Group II N=10	4 F 6 M	30.7	14.9	12,050	3:Daily 2:Twice/wk 2:Once/wk 1:Twice/mo 2:Once/mo	7 yes 3 no
Group III N=10	3 F 7 M	27.0	6.75	13,100	5:Daily 3:Twice/wk 2:Once/wk	8 yes 2 no

Table of Subjects' Driving Experience

Table 1.

Figure 2. illustrates a portion of the slide sequence between Temple and First Streets. The slides in Fig. 2 are the same as those shown to Subject Group II, having had all the high-rise buildings in the background removed. An example of the technique of clue removal from the slides is illustrated in Figure 3. The first slide shows the start of the trip as seen by the first group of subjects, with high rise buildings left in the picture. The second slide shows the same scene, except that the high-rise buildings have been removed.

Protocol

At the beginning of the presentation to each subject, a standard set of instructions was read and an interview technique was employed as the subject progressed through the sequence. The interviews were recorded using a small cassette recorder and transcribed, the protocols becoming the basis for analysis of each subject's behavior. The basis of the interview technique was to get the subject to talk as much and as freely as possible about his experience while he was experiencing the sequence. At each decision point he was asked to describe how he was making the decisions and what he noted in the environment that was useful.

Experimental Results

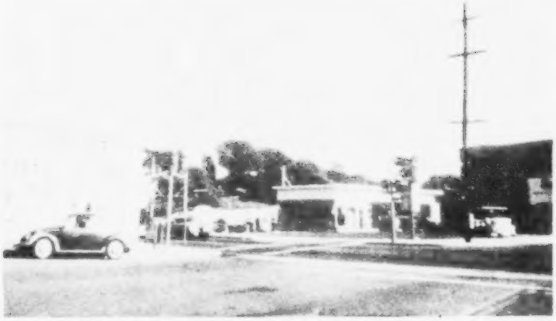
After all subjects had gone through the slide sequence, the interview recordings were transcribed and coded for subjects' decisions whether to turn left or go straight ahead at each of the five decision points. These appear in summary form in Table 2, along with totals of

1.

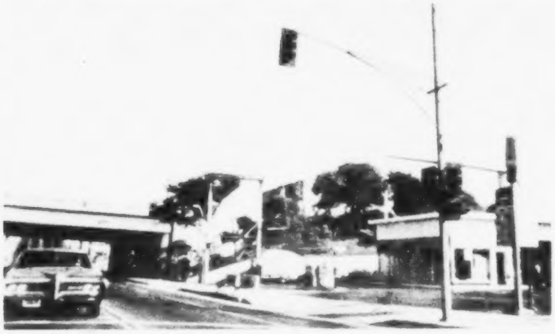
2.

3.

4.



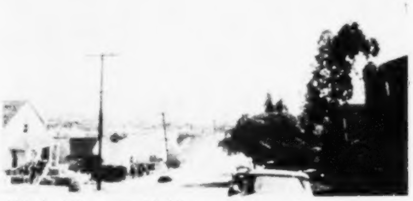
5.



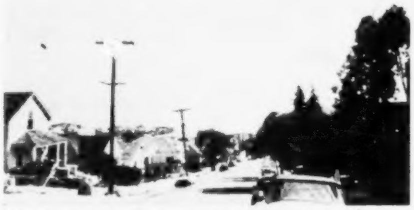
6.

Sample Slide Sequence: Beaudry Ave. Between Temple St. and First St., Showing Left Turn at First St. (Choice Point No. 3).

Figure 2.



High-Rise Buildings Present



High-Rise Buildings Removed

Sample Slide at Start of Simulated Trip, Showing Technique of Clue Removal
Figure 3.

"left turn" and "straight ahead" decisions for each of the three subject groups.

Results for the three groups are summarized in Table 3. By inspection it is apparent that there was little difference in overall branching behavior between Groups I and II, suggesting that removal of high-rise buildings from the slide sequence does not correlate with any meaningful difference in branching behavior. A striking difference occurs in the branching behavior of Group III, which experienced the slide sequence with all high-rise, and Freeway structures removed. A non-parametric analysis was performed to compare behavior between the three groups, testing the likelihood whether the three groups could have come from the same population. The branching behavior scores for the three groups were compared as (k) independent proportions, resulting in a value of $X^2=20.59$. The groups can be said to be significantly different at the $X^2_{.005}$ level.

Subject	Choice Point Number					Subtotals	
	1	2	3	4	5	Left	Straight
1. (M)	L	L	L	L	S	4	1
2. (F)	L	L	S	S	L	3	2
3. (M)	L	L	L	S	S	3	2
4. (F)	L	L	S	S	L	3	2
5. (M)	S	S	S	L	L	2	3
6. (M)	S	S	L	S	L	2	3
7. (F)	S	S	L	S	L	2	3
8. (F)	S	L	S	S	S	1	4
9. (M)	L	L	S	S	S	2	3
Subt. L	5	6	4	2	5	22	
Subt. S	4	3	5	7	4		23

Subject Group I: Summary of Branching Behavior

Subject	Choice Point Number					Subtotals	
	1	2	3	4	5	Left	Straight
1. (M)	S	L	L	S	S	2	3
2. (M)	L	S	S	S	S	1	4
3. (F)	S	L	S	S	L	2	3
4. (M)	L	L	L	S	L	4	1
5. (M)	S	S	S	S	L	1	4
6. (M)	L	L	L	L	L	5	0
7. (M)	S	L	L	S	L	3	2
8. (F)	L	L	S	S	L	3	2
9. (F)	S	L	S	S	L	2	3
10. (F)	S	S	S	S	S	0	5
Subt. L	4	7	4	1	7	23	
Subt. S	6	3	6	9	3		27

Subject Group II: Summary of Branching Behavior

Table 2.

Subject	Choice Point Number					Subtotals	
	1	2	3	4	5	Left	Straight
1. (M)	L	L	L	S	L	4	1
2. (M)	L	L	L	L	L	5	0
3. (F)	L	L	L	S	L	4	1
4. (M)	L	L	L	L	L	5	0
5. (F)	S	L	S	L	L	3	2
6. (M)	L	S	S	S	L	2	3
7. (M)	L	L	L	L	L	5	0
8. (M)	L	L	L	L	L	5	0
9. (F)	L	L	L	L	L	5	0
10. (M)	L	L	L	L	L	5	0
Subt. L	9	9	8	7	10	43	
Subt. S	1	1	2	3	0		7

Subject Group III: Summary of Branching Behavior

Table 2. (Continued)

The overwhelming preportion of decisions made for left turns in the third group (43 left, 7 straight) is underscored by the fact that 6 of the 10 subjects made only left turns at all 5 choice points. In group I, none of the subjects made 5 left turns, and in group II only one subject did.

A statistical analysis of comparative branching behavior by choice point was also performed (Table 3.). The small numeric values necessitated combining groups I and II, and then comparing the sum with group III. Of the five choice points, turning behavior varied significantly at #1, 4, 5. Values of X^2 and levels of

Group Number	Choice Point Number					Totals	
	1	2	3	4	5	Left	Straight
I	5L 4S	6L 3S	4L 5S	2L 7S	5L 4S	22	23
II	4L 6S	7L 3S	4L 6S	1L 9S	7L 3S	23	27
III	9L 1S	9L 1S	8L 2S	7L 2S	10L 0S	43	7
Values of X^2	* 5.05	* 1.65	* 3.79	* 8.37	* 4.81	20.59	
Level of Significance	>.05	<.05	<.05	>.01	>.05	> .005	

*Asterisked values of X^2 computed by combining scores for Groups I and II and comparing the combined score with Group III.

Summary and Statistical Analysis of Branching Behavior by Groups I, II, and III

Table 3.

significance are shown in Table 3. The task must, however, be interpreted in a sequential cummulative sense. e.g. that the decisions made at prior choice points do influence those made at later choice points, and so the choice points are not independent of one another.

What can be said about the radically different search behavior of group III? First, it should be noted that the task was not just to find the freeway, but also to enter it, going south (the subjects' original direction). Among the third group of subjects, 9 turned left at the first choice point, and the tenth turned left at the second. All these subjects were told they had crossed the freeway even if they didn't detect it within a long block of their turn. They all then knew how close the freeway was, and that there were no streets paralleling the freeway between it and Beaudry Avenue. So if the task can be described as one having both distal and proximal components, then all subjects in the third group could be said to have been in a proximal search mode after their initial left turn. In this sense they were in a similar situation to their counterparts in the first two groups, who could see elements of the freeway structure. Even though group III had a high proportion of sightings of clues directly associated with the freeway, such as grade change, signs, landscaping, etc., their behavior suggests the possibility that these other proximal clues were not good enough--that they sought a sighting of the object itself (freeway structure) and were willing to risk crossing to the wrong side of the freeway repeatedly in order to do so.

The observation that the presence or absence of the high rise buildings in the background (these buildings are all part of the Bunker Hill Urban Renewal Project, just east of the Harbor Freeway) made no significant difference between the performance of groups I and II, suggests the possibility that tall buildings are of little use as clues in this type of task. The only evidence that they might be of some use was an observation by three subjects (in group I) that if all else failed, they "might go downtown, expecting to find more information there".

Clues Sighted

During the experiment, subjects were encouraged to point out the clues that were useful in making their branching decisions. In attempting to interpret the variance in branching behavior, the results of the clue sightings should be noted. A striking result occurs in the numbers of clues sighted among the 3 groups of subjects. The difference in the overall number of clues sighted (109, 78 and 182 respectively for groups I, II and III) suggests another interesting change occuring with group III. With the greatest impoverishment of environmental clues from the simulation sequence, the total number of clue sightings increased drastically! Further, the difference between groups I and II was not apparent in the branching behavior comparison. It would be difficult to attribute a difference of this magnitude to inherent differences in the subject groups, given their similarity and the controls introduced. Rather, it suggests the possibility that, in the absence of the normal clues, subjects may have engaged in a more detailed scanning which would not otherwise have been employed.

Protocols from all subjects (N=29) were coded for all clues sighted by the subjects, and have been arranged in rank order according to the number of times they were sighted by each of the three sets of subjects. (Table 4). In all, 24 different clues were sighted with a total of 369 sightings made by all three groups

Rank	Type of Clue Sighted	Number of Sightings
1	Concrete Freeway Structures	17
2	Freeway Ramps	14
3	Change in Grade	12
3	Signs	12
5	Major Cross Street	10
6	Buildings as Reference Points	6
7	Traffic Direction	4
7	Freeway Furniture (guard rail cyclone fence, etc.)	4
7	Right-of-way Landscaping	4
7	Narrowing of Street	4
7	Traffic Light (Signal)	4
12	Traffic Density	3
12	Street Design	3
12	Distance Traveled	3
12	Road Divider	3

Group I: Environmental Clues Sighted

Rank	Type of Clue Sighted	Number of Sightings
1	Concrete Freeway Structures	17
2	Signs	13
3	Change in Grade	10
3	Freeway Ramps	10
5	Narrowing of Street	6
6	Right-of-way Landscaping	5
7	Buildings as Reference Points	3
8	Major Cross Street	2
8	Freeway Furniture	2
8	Traffic Direction	2
11	Traffic Density	1
11	Spaces Between Buildings	1
11	Street Design	1
11	Traffic Light (Signal)	1
11	Change in Building Types	1

Group II: Environmental Clues Sighted

Table 4.

Rank	Type of Clue Sighted	Number of Sightings
1	Change in Grade	26
2	Signs	23
3	Right-of-way Landscaping	18
4	Freeway Furniture	16
5	Major Cross Street	14
6	Traffic Density	12
7	Spaces Between Buildings	10
7	Traffic Direction	10
7	Traffic Light (Signal)	10
10	Street Design	8
11	Change in Building Types	6
12	Road Divider	5
12	Shadows	5
12	Service Station	5

Group III: Environmental Clues Sighted

Table 4. (Continued)

of subjects. Table 4 lists the number of sightings and the ranking within each group (limited to the top 14 clues for each group).

A Kendall Coefficient of Concordance test (W) was performed, comparing the rankings of clues by the three groups of subjects. (12). (W) measures the extent of association among (k) sets of rankings of (N) entities. In this case k=3 (the three groups of subjects) and N=14 (the 14 clues). The Coefficient of Concordance is more useful in this case than either the Spearman or Kendall Rank Correlation tests since the latter are more suited to tests where k does not exceed 2. Correcting for tied scores, s=1019.75 and W=.515. Using the formula X^2 s ÷ 1/2k N (N+1) we convert to a Chi^2 measure ($X^2=20.1$). Since $X^2.05$ at 13df=22.36, H_0 cannot be rejected, and we can say that the k rankings (groups I, II and III) are unrelated at the .05 level. This test supports the hypothesis that the progressive impoverishment of the selected environmental clues does make a difference in order of importance of the clues sighted.

The numbers of sightings of the top 7 clues allowed the use of a Chi^2 test of k independent proportions, contrasting the number of sightings between groups. Table 5 contains the result of this analysis. Among the seven clues, only concrete freeway structures and sightings of what 'looked like ramps' had significantly different proportions among the 3 subject groups. (Since N is too small for the other clues, they could not be tested). The other 5 clues retained their relative strength across the three subject groups, suggesting their importance is not affected by clue impoverishment. This analysis by ranks suggests a fairly strong preliminary indication of those clues which are important for this type of task, and their order of importance.

Type of Clue	Number of Sightings			Value of X^2	Level of Significance
	Group I	II	III		
Signs	12	13	23	1.39	$<.05$
Grade Change	12	10	26	.683	$<.05$
Concrete Fwy Structures	17	17	4	27.34	$>.005$
Landscaping	4	5	18	4.05	$<.05$
Major Cross St.	10	2	14	3.29	$<.05$
Typical Fwy Furniture	4	2	16	5.33	$<.05$
Ramps	14	10	2	17.5	$>.01$

Seven Highest Ranking Clues: Test for Similarity of Ranking Across 3 Groups of Subjects

Table 5.

As Table 5 shows, five of the seven clues did not significantly differ in their rankings among the three subject groups. This means that for these clues, the removal of other clues did not change their relative importance. The two clues which were significantly differently ranked, Concrete Freeway Structures and Ramps, were both clues removed from the third slide set. These were important enough to the other two groups of subjects that their removal caused the Kendall Coefficient of Concordance analysis to show that the overall rankings were unrelated. This adds evidence to the possibility that the order of importance of clues is in order of proximity to the object being sought. Inspection of Table 4. suggests also that clues are ranked in order of proximity.

A number of other observations were made by subjects which were not directly related to specific environmental clues. A total of 24 observations were made by subjects indicating that they would be moderately to extremely frustrated by a similar experience in the real environment. By subject group, the observations were: group I = 8; group II = 9; group III = 6. Nearly every one of these observations was accompanied by a volunterred anecdote about a frustrating experience in Los Angeles at trying to get onto a freeway. Also, the progressive impoverishment of clues was consistent with subjects' progressive inability to connect the task route to a cognitive map. Related to the difference in overall numbers of clue sightings, it suggests that subjects are more active in their scanning for environmental clues in the absence of a cognitive map, which was to be expected.

Summary and Conclusion

The experiment supports the hypothesis that path choosing behavior will be modified in the absence of key environmental clues. This is supported by a statistical difference in path-choosing behavior at the .005 level of significance. The sighting of freeway structures themselves proved dominant as the clue most affecting subject's decision making. The presence or absence of high rise buildings in the background played little role in changing the path-choosing pattern, suggesting the limited importance of buildings as clues in a task of this sort. In spite of the presence of numerous other clues indicating the presence of a freeway, and the knowledge that they were parallel and very close to it, subjects who had not actually seen the freeway structure itself persisted in turning left in search of the entrance, while the others had a mixed strategy of paralleling and turning left.

Environmental clues which were sighted by subjects fell into the following overall (descending) order of importance: signs, grade change, concrete freeway structures, typical freeway furniture (fencing, guard rails, standards), ramps, traffic intensity, traffic direction, traffic signals at intersections, narrowing of street, street design (width, curbs, shape, striping), buildings as reference points, open spaces between buildings.

There was a statistical difference at the .05 level between the rank order of importance of the clues among the three groups of subjects, a large part of which can be explained by the absence of important clues from the third slide sequence. Generally the order of importance of clues remains stable across the 3 groups, indicating a strong consistency of clues used by drivers at this task. The most clue-impoverished slide sequence, however, elicited a far more active scanning for clues as indicated by the large difference in total numbers of clue sightings.

The simulation technique of this experiment is primitive and was applied to a particular and very small piece of the city through which users find their way. Hence the results, though clear for the test site, can not be readily generalized. It is recognized that experimentation with this type of problem is inevitably plagued by many environmental and human variables which can not be adequately controlled. In spite of these limitations in the methodology, the experiment yielded clear and statistically significant results. This suggests that a more sophisticated application of this methodology would be expected to produce useful information about path-choosing behavior. Such information would have direct design applicability to the problem of increasing the legibility of spatial sequences for city users.

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CONTINUOUS FLOW TRANSPORTATION NETWORKS AS NEW URBAN PATTERNS

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Prologue

One of the most important problems in planning highway systems is to determine which transportation network will best serve the urban area. The decision allowing for the appropriate network must be made so as to minimize the road area in cities and to provide rapid passenger service.

In planning, the future value of time and the notion of time as a saving device for individuals making trips in urban areas must be clearly recognized. In addition, network systems, herein proposed, which will permit the passenger to travel in less time and greater safety will also show a significant reduction of pollution in the total urban area, an important factor in ecological planning today. It is also fairly obvious that an increased speed of displacement (velocity) is potentially capable of enlarging the urban tissue, thus avoiding megastructures, probable germs of future slums.

The theoretical research discussed here should not, however, be understood as a system to build future cities(1). Circulation is an important determinant but not a unique one in shaping urban form, and the biological or organic aspect of growth cannot be schematized by simple geometric configurations. Although the research was based on a new type of space partition, for example, hexagonal versus orthogonal, the unfamiliar aspect of such geometry should not conceal its major advantages which will be specified later. Care, of course, must be taken not to make such a new transportation network too complete in structure, too specialized, or too inconsistent with other customary dimensions of the city.

As existing systems are viewed as far from optimal, understanding the properties of the transportation networks may demonstrate the processes of searching for alternatives to existing systems and will clarify operational definitions that can be used to judge these alternatives once found(2).

This investigation of transportation networks attempts to show that there are new properties of flexibility which will enable planners to work out better and, indeed, more economical solutions for producing more efficient circulation systems(3). We shall present first a brief discussion of parallel thinking in fields of regional science, economics, city planning, and mathematics. Following this, various pertinent definitions and relationships shall be defined and three models of hypothetical cities put forward as illustrations. Finally, the new transportation network systems developed by the researchers shall be described and their advantages as more efficient alternatives to the transportation systems currently in use shall be studied in detail, all this with an eye toward future practical applications of the ideas proposed.

Background

This study is an effort to apply the principles of the theory of graphs to abstract concepts of transportation network configurations and was suggested by work done by Professor Robert G. LeRicolais to develop and evaluate the Trihex Grid system as a geometric alternative to existing and other proposed urban transportation designs(4).

This type of approach, that is, imposing grid on urban areas, was developed through planning theory. The use of hexagonal patterns appears in various economic and geographic theories. Walter Cristaller(5), August Losch(6) and, more recently, H. C. Bos(7) have applied hexagonal patterns in their attempts to determine the most economical locations for activities in an economic landscape. Beckmann proposed that for a condition in which all locations of an urban plan are to be provided with goods, the pattern of market areas must consist of one of the three simple types of regular polyhedrons like triangles, squares, hexagons - that will form a regular network(8). Among these networks, hexagons are optimal, in the sense they cover a given area with the least transport cost(9). This approach was further developed in numerous central place studies(10).

The main question that still remained was whether the rectangular road grid, so often found in reality, would be found economical and efficient with respect to transportation and with respect to uniform spread of land development and urban activities. This orthogonal pattern of streets in cities has been so well fixed in our minds--it is this geometry of right angles that has formed almost the exclusive basis for determining the arrangement of urban streets and lots, that it hardly occurs to us that city streets might have an entirely different pattern.

The process of increasing investment of public and private funds in new and existing urban areas has been continuing at the same time as the growth in amount of traffic. The lack of coordination between the public and private sectors of society has led only to unstructured complexity and reduction in movement time within our urban areas. Traffic engineers have introduced transitory measures to reduce both travel time and distance by attempting to provide areas of smoother traffic flow of the stop-go type and sometimes of the steady flow type. So far, however, these measures have only succeeded in either relocating the problem at an adjacent area or making the areas itself useful for traffic but worthless as an environment (the dilemma of not recognizing that traffic serves the city, not vice-versa).

In contrast, the Buchanan Report, Traffic in Towns(11), suggested a hexagonal grid as one alternative circulation system for the complete redevelopment of a central London block, while a more recent proposal by Christopher Alexander(12) was completely based on an orthogonal pattern of a larger scale than that existing today. Alexander's design trebled the average speed typical for urban areas (from the present 15 mph to 45 mph) and increased mean trip length considerably. However, none of these previous studies attempted to deal with overall communication problems in cities.

Models developed by Frank Harary(13) and methods for the use of topology and geometry, some developed long ago in 1752 by Leonhard Euler(14) and others recently advanced by Christian Werner(15) were employed by the researchers here to construct abstract concepts of networks configurations. All of these tools aided the researchers in the study of the properties of three-dimensional networks and in the estimation of the parameters for the selection of the most appropriate or the theoretically "optimal" design.

Testing of Three Models of Evaluation in Hypothetical Cities

Initially a comparison of the trihex grid system (tessellation of regular triangles and hexagons) with the orthogonal grid (see Figure 1) as a transportation network and as an urban space partition was made both to gain a basic understanding of this innovative design and to begin to develop a rational approach for developing other transportation networks.

For this comparison, it was assumed that each system was superimposed on a city of the same area with population in the cities distributed at equal density. In all the special cases in this study, the location of nodes, level of activities, number of jobs, were assumed of the same volume for easy comparison between the different types of networks. Also assumed was the same mode of transportation so that the mode of travel is only regarded as being a function of the geometry of the network. It should be understood that the choice of mode of travel thus depends upon the value of time and upon cost for trips of different types(16).

First, the number of intersections, distance between intersections, length of path, and number of regions were determined for each of the models. Here it was assumed that minimization of number of intersections, and maximization of distance between them may increase speed, while minimization of length of path may decrease travel cost in terms of travel time. These were defined as the dependent variables of the systems. Without destroying an area's accessibility (as defined below), those variables provided the measures of the efficiency of the systems.

In general terms, for this study, accessibility was defined as the measurement of people's desire to minimize their trip length to nodes of activities, or of their desire to minimize transportation costs to the whole range of urban activities available such as shopping centers and office complexes which are also represented by employment(17). It was also found possible to show by further development of the gravity-type formula of accessibility (assuming the same density) that the level of accessibility is a function of travel time or trip length.

For comparison between the types of networks, the following formula will represent the ratio of accessibility between the orthogonal grid and the trihex grid, which is the invert ratio of travel time:

$$\frac{A'_o}{A'_*} = \frac{\Sigma T_*}{\Sigma T_o}$$

Where
A = Accessibility
T = Travel Time

Note: o sign represents orthogonal system
* sign represents trihex system

In order to compute the cost benefit of the different networks, the model developed by Christian Werner was used. His model was intended to estimate the total cost of a network. Werner stated that transportation is composed of:

a. "construction cost" - defined as the sum of all costs which depend only on the length of the route.

b. "flow cost" - defined as the sum of all costs which depend on the length of the route and the magnitude of flow on the route.

Werner assumed that the two cost functions are linear functions of distance of route and size of flow:

$$\underline{T = C + f\ K}$$

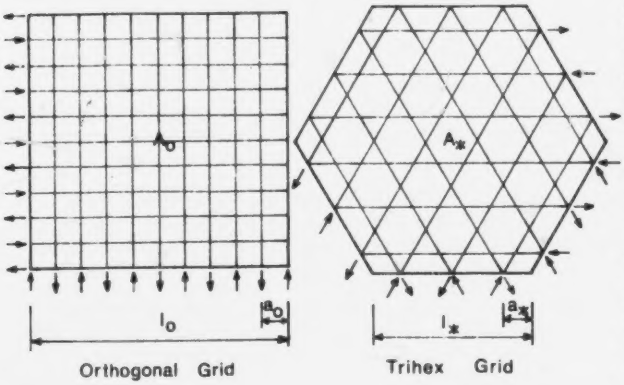
where

T = total cost per unit length
C = construction cost per unit length
K = flow cost per unit length
f = represents the flow volume

*The costs taken into consideration are commonly expressed in different time units(18).

We, in addition, assumed that transportation cost is either proportional to geometric distance or is, at any rate, a function of this distance. This is true only when the transportation network will be constructed along with a plan and if construction costs per unit length are equal everywhere. It may be shown by Werner's model that gain in time and length of path will decrease the total cost of transportation.

We have pointed out these relevant assumptions and evaluative procedures employed in the hypothetical comparison of an orthogonal system with a trihex grid (Figure 1) so that the reader may better understand the results of that comparison, as well as the results of comparisons of continuous flow networks to be described later.



Orthogonal Grid Trihex Grid

Figure 1.

The topological variables used in the study are:

l	boundary length
n	number of units in a boundary
a	unit length or the distance between intersections
A	area or density of population, activities, etc.
P	number of regions or sites
E	number of segments or partitions
C	number of corners or intersections
L	total length of path

The topological relationships used in this study are as follows:

Orthogonal Grid	Trihex Grid
$P_o = n^2$	$P_* = (9n^2 + 6n + 4) : 4$
$E_o = 2n^2 + 2n$	$E_* = (18n^2 + 12n) : 4$
$C_o = n^2 + 2n + 1$	$C_* = (9n^2 + 6n) : 4$
$L_o = E_o$	$L_* = E_*$

Note: The areas are the same, therefore the ratio of boundary length between the orthogonal and trihex grid is: $\frac{l_o}{l_*} = 1.615$

With the use of these topological relationships, quantitative analysis, applicable to any given unit length and employing a limited number of realistic constraints, may be illustrated in the three cases below.

Model I

-Assuming cities of the same area of a very nearly equal density, and total length of path as constant - where expenditures for road construction are the same.

The mathematical results of analysis showed that the number of intersections was decreased by 9%, and the number of regions served was increased by 11% in the trihex grid system. It may be said, then, that in this manner the accessibility level was increased without changing the construction cost.

Model II

-Assuming cities of the same area of a very nearly equal density of population, activities, etc. Distances between intersections were kept the same.

Here, mathematical results showed that, while the model maintained almost the same accessibility levels, the cost of construction was still reduced by 13.5% in the trihex grid system. Movement speed was increased by reducing the number of intersections by 21% in the trihex grid system.

Model III

-Assuming cities of the same area of a very nearly equal density of population, activities, etc., the number of subsectors (regions) into which the transportation system divides (the smaller equal areas) is held constant.

The mathematical results in this case indicated that by the given constraints, the same number of regions were served and the cost of construction was reduced by 12.6%. As in the second model, the speed was increased by reducing the number of intersections by 18% in the trihex grid system.

To emphasize the greater efficiency of the trihes system, we may also show the relationships of the pedestrians to the partitions of the networks (the segments which are on the boundaries of the sites and form the space between the movement channels). In general, the paths for pedestrians in the trihex and orthogonal grids were tested by comparing their lengths assuming a distance m = r = 1 from the centre 0 to reach any point a, b, c, d, e, f, going to any of six directions and thus equivalent to the trigrid (Figure 2).

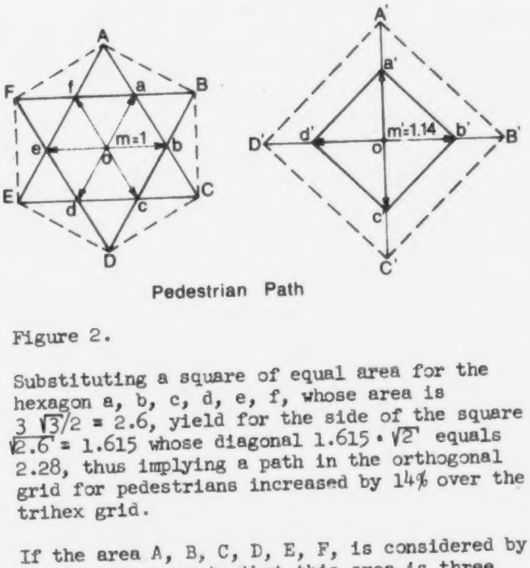


Figure 2.

Substituting a square of equal area for the hexagon a, b, c, d, e, f, whose area is $3\sqrt{3}/2 = 2.6$, yield for the side of the square $\sqrt{2.6} = 1.615$ whose diagonal $1.615 \cdot \sqrt{2}$ equals 2.28, thus implying a path in the orthogonal grid for pedestrians increased by 14% over the trihex grid.

If the area A, B, C, D, E, F, is considered by itself, we may note that this area is three times the area a, b, c, d, e, f, i.e., 2.6 x 3 = 7.8 units. The equivalent area of an orthogonal system yields a side of the square, $\sqrt{7.8} = 2.8$. Using the electrical analogy (refer also to later discussion on continuous flow networks), between A and D, let us say, $I_* = U\,(1/4)$, if we consider only a unique direction in the trihex at A. Movement through points A', B', and C' in the orthogonal system yields $I_o = U\left(\frac{1}{(2.8 \times 2)}\right)$; $R_o = 5.6$, the reduction being $R_*/R_o = 28.5\%$, in favor of the trihex grid. In these formulas, I is the current in Amps, U the voltage, and R the resistance in Ohms. In addition, travel in the orthogonal system through points A', a', b', c' and C', in comparison to movement in the trihex grid through points A, a, b, c, and D produced mathematical results indicating a decrease of 18.5% in resistance in length of path, once again in favor of the trihex.

Pedestrians in the trihex system can always follow the minimum path. Hence, the average distance that the individual must travel to get to the system is minimized(19). That is, there is an increase in the level of the individual's accessibility. Thus, the trihex vehicular grid, coupled with the trigrid for pedestrian circulation, produces the best conditions for an integrated and ordered system of a differentiated circulation where cars and pedestrians follow the shortest path.

Understanding the qualities of the trihex grid system will undoubtedly help traffic planners to meet the constraints that occur in the real world. Accessibility, number of intersections, length of segment, and total length of path, though conceptually defined here, have a direct counterpart in reality. Accessibility is a function of the number of subregions created by the transportation configuration. The greater the number of these subregions, the shorter the average distance the individual must travel to get to the system, hence, the minimization of his travel time. The fewer the number of intersections, the greater the speed of travel and the reduction of the cost of the system. As path segments between intersections grow longer, travel time is reduced if subregion accessibility is maintained. The total length of transportation paths could be considered to be directly analogous to the cost of construction of the system. Of course, the scale between intersections is the real problem, depending greatly on the density and nature of the new city constructed or conceived.

All of these are certainly relevant issues in an age when attempts are being made to deal with complex problems of urban transportation with limited resources. This brief account of the comparison of a hypothetical orthogonal and trihex grid configuration may shed some light on how these resources could be allocated more efficiently in meeting transportation objectives.

Continuous Flow Networks

This portion of the work centered on the idea of continuous flow networks in different geometric configurations. A more comprehensive view was taken both in terms of the number of geometric configurations considered and the method of organizing and evaluating those systems.

The primary goal was to construct a continuous flow network which would provide an individual independent movement system flexible enough to enable superimposed circulation, for example, a mass transit system of a higher degree.

The main objective in this construction was the achievement of a gain in time for movement in a "dynamic" system versus a stop and go system. The increase in speed could be achieved by the reduction of the number of decisions to be made during movement in the system and in the interchanges.

Five fundamental conditions were imposed on the networks considered in this part of the study:

1. Complete separation between cars and pedestrians was maintained.
2. No stopping for cars in the streets was allowed - streets were solely for movement (gain in average velocity).
3. Parking garages and stopping places were located at each change of level.
4. Additional circuits at low speed for service, delivery, and garbage collection were attached.
5. Increase in velocity was expected to increase output, that is, a measure of number of cars per hour.

The problem was to quantify the outputs of three typical networks - orthogonal, trihex, and hexagonal. Certain rules had to be observed in order to make coherent deductions, among which the ideas of area and perimeter were most significant. It seemed clear that the comparison was to be made between networks of identical areas. It was also remembered that the essence of the trihex system is based on the combination of two meshes: a primary network of fast circulation along the six directions of the solomon's seal - and a secondary system based on the hexagonal partition of the plane. It then follows that the reduced velocity provides for the possibility of "weaving" at the intersections.

Thus, we may construct an analogy between the motion of electrical energy and movement in a circulation network (20). Keeping the analogy $V_w = R\,I^2$, where V_w is the total energy, R, the resistance (in ohms), and I, the intensity in Amps, we have for the total number of vehicles following a street at a velocity V, $V_w = \sum \frac{m\,v^2}{2} = R\,I^2$, which can be expressed in terms of kilometers per second or in watts. In other words, for a given output and a given resistance, the velocity is proportional to the car output. This, of course, may not be true in cases where resistance may occur. for example, in the form of sinuosity of the road, the changing nature of terrain, and the maintenance of safety distance between cars. The hydraulic approximation of a loss of head proportional to the output seems to have some validity here.

Further development of the notion of street output as a function of velocity may establish velocity as an significant factor in continuous flow networks.

We should now state the law of continuity where the street output in a continuous flow network is a linear function of the section of the street and of the velocity and when time is an independent variable:

$$Q = S \cdot V$$

where

Q = the street output
S = section of the street
V = velocity

For discontinuous systems, the street output may be expressed as a function:

$$Q = \gamma t \cdot S$$

where

t = time taken to get to the velocity in the system
γ = the acceleration which varies in square (space time), that is: $\frac{d^2x}{dt^2}$

It is interesting to note the amount of energy vanishing at each stop signal, absorbed by the brakes and in fact doubled by the acceleration imparted after the stop. Such a condition helps us to understand how desirable a system of continuous flow or constant flow may be, especially at high velocity.

The five continuous flow transportation networks that were developed are as follows:

Bihex Grid - Two Level Continuous Flow Network. The Bihex system was constructed as a hexagonal grid on two levels. The continuous flow was provided by a one-way system. The two levels were superimposed one on the other in different directions, creating the combination of intersections with two choices and intersections with no choice (Figure 3).

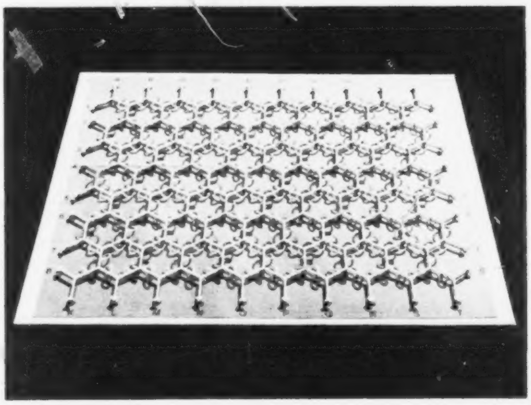


Figure 3.

The properties of this system allow for development in different directions without the destruction of the system and permits change of direction of flow in 120° angles. The system could be developed in new central business districts (henceforth known as C.B.D.) where there is a need to optimize location of activities. The bihex grid system creates a new type of space partition (Figure 4) which necessitates new types of buildings, the floor construction of which, for example, can bring about financial savings of more than 30 per cent over orthogonal systems. New designs for movement channels may also be conceived.

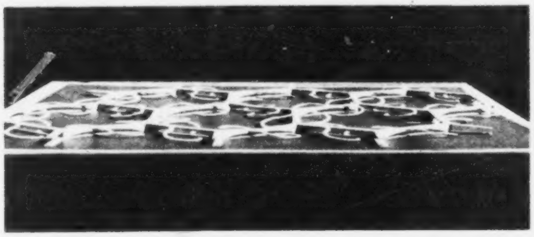


Figure 4.

Grid-Iron - Two Level Continuous Flow Network. The Grid-Iron system of continuous flow was constructed as an orthogonal grid on two levels. The continuous flow was provided by a one-way street system on two levels. The two levels were superimposed one on the other in different directions, creating the combination of intersections with three choices and intersections with no choice, but all one-directional flow (Figure 5).

This system could be developed in existing C.B.D. where there is a need for traffic of continuous flow and where the development follows the orthogonal system.

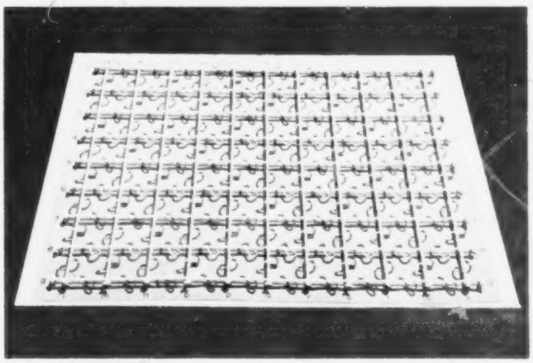


Figure 5.

Hexagonal Grid - Continuous Flow Network by "Weaving". To provide continuous flow in this system, in each region, that is, in each hexagonal space, two segments of the hexagon were situated on two levels so as not to interfere with the traffic coming from different directions (Figure 6). The weaving was made possible by the use of ramp of 3% slope. The hexagonal pattern involves jagged movement, therefore it might be used in urban areas where economy in construction of streets and buildings becomes more important than reduction of velocity. Still, a considerable increase in travel time saved may be attained by introducing such a system.

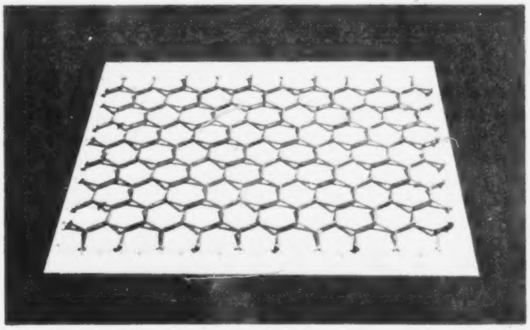


Figure 6.

Grid-Iron - Continuous Flow Network by "Weaving". The Grid-Iron is an orthogonal system which provides movement in straight lines. The continuous flow was achieved by "weaving" at intersections. Each intersection was, once again, constructed in two levels so as not to interfere with the traffic coming in different directions (Figure 7). Change in the direction of flow, as in all the types of "weaving" networks, was made by loops on ground level.

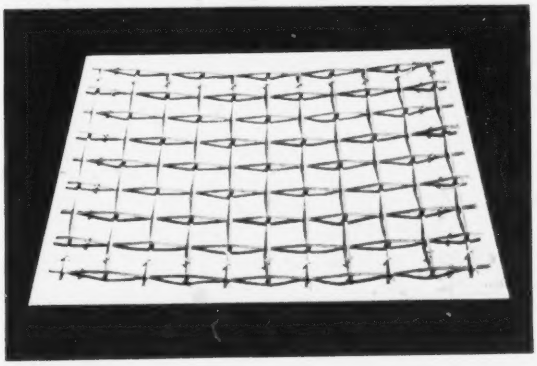


Figure 7.

Trihex Grid - Continuous Flow Network by "Weaving".
The Trihex Grid is a tessallation of regular triangles and hexagons to be used by vehicular traffic. The continuous flow of traffic was achieved by "weaving" at intersections. Here too, each intersection was constructed in two levels so as not to interfere with the traffic coming from different directions (Figure 8), this composition resulting in greater travel safety. This system provided three courses of traffic flow in straight lines. In the system it was also possible to achieve continuous flow by constructing a change of levels only in 120° and with fewer interchanges. This arrangement may also increase the speed of traffic.

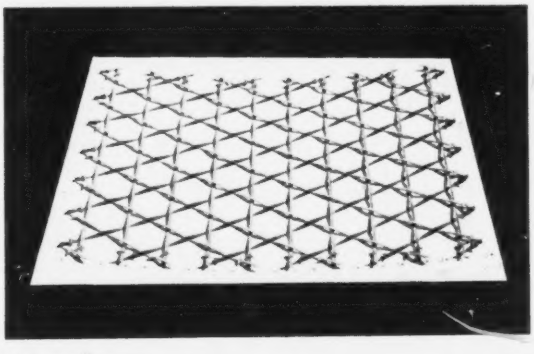


Figure 8.

To facilitate study of the properties of each network system, each one of them was represented in graph form. On each graph, the flow direction was indicated by an arrow and every mode was located with reference to X and Y axes. (Whether one chooses to speak of a node of activity or of an intersection depends largely on the scale of the plan under discussion. This particular part of the study is by no means quantitative - that is why we refrain from giving any dimensions for future city blocks. The need for such details calls for much closer examination.) For purposes of comparison, it was assumed that each system was planned on an equal area and that the size of segment (distance between pairs of nodes) was the same. In such generalized grid networks, travel times and costs could be calculated on the basis of distance between origin node and destination node co-ordinates.

Each system was evaluated in terms of routes from origin to destination by determining the length of path first in terms of the "effective path" which included some of the constraints of the system, such as direction of flow, number of intersections, and change of levels. Secondly, this length was compared to the "theoretical path" which was free from the above-mentioned constraints.

The "effective ratio" was represented as "effective path" over "theoretical path". This ratio was used as a measure of system efficiency, which was defined as the minimum total time and distance from place of origin to destination. It should be evident that in an efficient system, the ratio is equal to "one". In addition, the effective ratio, that is, a function of length of path, was used in the comparisons between the systems as a measure of the total cost per unit length of transportation. Werner's model (described previously) was employed to interpret comparisons between the effective ratios of the systems in terms of the cost and benefits of each system.

To take one brief example, the effective ratio of the trihex grid by "weaving" taken in proportion to the grid-iron system by "weaving" may indicate potential reduction of construction cost by 16%. In fact, the trihex grid was found most efficient of the developed models.

Such mathematical insights may be significant in designing transportation systems supporting great numbers of activities which require large amounts of goods and services.

Conclusions

The main problems for realistic application of transportation networks developed in this study should be kept in mind. First, the networks must remain flexible while secondly, they must be able to become specialized enough to handle the intense density areas that urban configurations inevitable develop.

It was found that the trihex grid, although it may not be applicable in its total rigidity, nevertheless, contains elements which are superior to the present principles used for street layout. The trihex grid can be adapted to topography without destruction of the nature of the system and the system can be made to work in an incomplete form either in adaptation to the topography or to the development process by deformation.

In addition, continuous flow networks provide for increased velocity of traffic and show an increase in the "coefficient k", when "coefficient k" was represented as output of cars in the proposed network over output of cars in the current system. Average output of the trihex grid in comparison with the grid-iron has been calculated as $k = 2.5$, based on average velocity of 40 mph in a continuous flow network. In the computation of the average velocity for the trihex network by "weaving", one must take into account the average number of jumps per trip where velocity is reduced.

With a theoretical increase of velocity in the continuous flow networks, population may decrease (assuming an identical time for circulation), largely to greater area and less roads per unit area. Other results due to increase in velocity are summarized as follows:

> Reduction of pollution (for a given traffic) since the time of travel is proportional to velocity.
>
> Extension of available suburban ground in proportion to increased velocity.
>
> Reduction of road area per unit area always on the basis of increase in velocity and increase of the region controlled by highways (minimum periphery for a given area).

What yet remains before us is evaluation of these systems not as elements unto themselves but as integral parts of the real world. The limited constraints of evaluation of the models developed in this study must be broadened to approach the complexity of the constraints of the real world. To be served, the individual must be more explicitly identified as must be the environment in which the system is placed.

In other words, these systems, until now geometrically generated and evaluated according to their intrinsic merits, must be investigated as integral parts of a larger more complex system the world of our urban fabric. Innovative designs such as the ones developed and discussed here may, indeed, prove valuable in the search for solutions to the pressing problems of the overcrowded cities of our era.

NOTES

1. This paper summarizes the methods and results of research done by Robert LeRicolais and Alexander Messinger, titled, "Transportation Networks as a New Urban Space Partition", Transportation Studios Center, Center for Urban Research and Experiment (CURE), University of Pennsylvania, U. S. Government Grant No. 2-01516-3-5325, Subgrant No. P69-794, May, 1970.
2. Ibid, pp. 24-25 and pp. 36-40
3. For this study, the efficiency of a trip was defined as the shortest time and distance from origin to destination and the efficiency of a system was defined as the minimum total time and distance from place of origin to destination.
4. For further information, see the article by Robert LeRicolais titled, "The Trihex: New Pattern For Urban Space", Progressive Architecture, Volume XLIX, No. 2, February, 1968, pp. 118-119.
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12: INSTITUTIONAL SETTINGS

ALCOHOLISM AND ARCHITECTURE: THE MYTH OF SPECIALIZED TREATMENT FACILITIES*

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Alcoholism as a treatable entity is not well established. Researchers in the field

> "cannot help being impressed by the paradoxes, inconsistencies, and differences in answers given by people with the same treatment roles and training. The variety of ideologies and conceptualizations indicate the complexities of problem drinking, the lack of agreement among workers in the field... Furthermore, an extensive review of the professional literature... (is) no more helpful than direct on-the-spot interviews and intensive discussions with personnel in the field".(1)

Nevertheless, specialized facilities for the treatment of alcoholism exist to serve only alcoholic clientele. These facilities are clinics, halfway houses, private sanitoria, special hospitals. Their programs are devoted exclusively to dealing with alcohol problems. Additionally, alcoholism sub-programs are often part of larger, more comprehensive programs. Places for treatment are wings of hospitals, a special cluster of cottages on the state hospital campus, one half of the total clinic space for the program.

This state of affairs poses enormous problems for the architectural researcher. If the purpose in the research is the essentially moral one of improving the facility to meet service program and client needs, one is stopped short by questions of what service program and what clientele, particularly if the provision of facilities is considered on the national scale. If the purpose is to assist more precise definitions of alcoholism, alcohol problems, and alcoholic clientele, what can the architect contribute? It would perhaps have been most sensible to postpone architectural inquiry pending better definition of the problems to be solved. However, the Architectural Consultation Section, NIMH, is bound to assist the development of NIMH-sponsored alcoholism treatment programs. NIMH is responsible for funding 30 million dollars' worth of comprehensive alcoholism service programs during the next two years.

The community-based alcoholism treatment service, the basic unit of the alcoholism treatment enterprise, is a complex system of widely disparate elements: a facility, an administration, a treatment staff, a program, existing community practices, legal constraints, economic considerations, governmental regulations, and consumers of services. The system is complex because its elements are so dissimilar, based on widely different units of measurement. Yet all these elements interact; they are interdependent. To ignore the inter-relationships is to obviate any findings.

To cover all the bases, a team of four was established to site-visit existing programs to investigate the relationship between space and treatment activities for alcoholic populations. The four consisted of a registered architect, an architectural consultant in mental health facility design, a sociologist, and a social worker knowledgeable in the functioning and administration of alcoholism programs. Together we site-visited over forty programs, most of them in four major communities. It was necessary to look at the full range of alcoholism services in each of these communities to fully understand the individual services visited. Additionally, our interest was in the community treatment enterprise as a whole that included the diverse individual services.

This paper will report on our visits. The initial methodology resulted in the identification of three major issues, rather than in "answers" to how to build for alcoholism services. The paper will present these issues, then suggest an approach to their resolution.

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Methodology: An Open-Ended Approach

Site-visiting involved three major tasks: interviewing patients and staff with an open-ended interview format; short-term participant observation of the functioning of the facilities; and fact-gathering via a standard form to gain a uniform picture of the diverse elements across all of the programs visited.

We interviewed as many staff and patients as possible (usually about four staff and four patients). Informal conversations with many others in the facility also took place. Staff were asked to describe the program philosophy and direction, to describe the methods of treatment, to describe the requirements for initiating and terminating treatment, and to discuss the yardsticks used to decide whether they were doing a good job. Secondly, staff were asked about the facilities they occupied: were they suitable to the conceptualizations, goals, and activities just described? What additional facilities were necessary? What changes would they like to make in the current facility? Given unlimited resources, what should be set up?

Patients were asked five open-ended questions: What brings you to this place rather than some other? What brings you here now? How do you spend your time, who do you talk to? Where are you going from here? Secondly, patients were asked the same questions about the facility as were staff.

Prior to each interview, the researchers identified themselves and the purpose of the visit, and gave assurances of confidentiality. The questioning generally led into more wide-ranging discussions that gave the respondant a chance to restructure the interview and say whatever he wished.

The participant observation consisted of sitting in on therapy sessions and spending several hours at a stretch in the facility, talking informally to people, taking notes of the researchers' own reactions to the space and the milieu, and generally developing an impression of the major features of the program. The researchers stayed apart from each other during this time, and often stepped out of their roles as insight-hungry professional surveyors. Because of the observation's short duration and of the cultural distance between the site-visitors and many of the clients and staff, the researchers consider much of the information and insight gained from this approach of minimal value.

Finally, a lengthy form was filled out by the director or assistant director of each service providing information on the financing and acquisition of the facility, the staffing pattern, the program description, relation to other agencies and services, and the caseload of the service.

In sum, this approach started with the minimal hypothesis that an observable relationship exists between space use and therapeutic activity. The immediate goal of the researchers was to define this hypothesis more precisely to serve as a basis for subsequent research. In light of the paradox mentioned in the introduction, it was felt important to leave the conceptualization of space-use for therapy as open as possible.

Observations: The Failure of Therapeutic Definitions and the Diversity of Facilities

Conceptions of alcoholism as a treatable entity varied widely. At least three conceptualizations were advanced. Alcoholism was explained as a:

Clinical entity. Clinical theories included analytic conceptualizations (confusion over sex roles with an alcoholic parent, for example) and more situational constructions (a handy device to resolve conflicts). While the researchers' collective grounding in psychoanalytic theory is not strong, it was possible to discern wide-ranging and often contradictory views.

Social problem. Younger, more radical therapists often tended to view 'alcoholism' as a labelling enterprise to insure social control of unwanted behaviors that clashed severely with 'normal' and 'accepted' behaviors. These therapists distrusted diagnostic categories and the use of professional devices to insulate therapists from full responsibility for their drinking clients. Yet at least one of these therapists' academic training was very much within the Freudian school.

Medical condition. Despite the absence of a causative bio-chemical agent, some therapists held the belief that alcoholism is ultimately biological in nature, and that a yet-to-be found drug ultimately might deal with the problem. At less sophisticated levels, one recovered alcoholic held firmly to an 'allergy' theory.

Generally, there was not much interest in discussing the theoretical underpinnings of alcoholism, despite the acknowledged disparities between pacticioners' views. Emphasis was placed much more on action to deal with immediate problems. At this level, a good deal of friction existed between treatment services, and it is at this level that the gross disparities in operation appeared.

Lack of conceptual agreement obviously goes hand in hand with enormously divergent approaches to treatment. These programs were self-defined, based intellectually on years of the director's experience in dealing with drinking problems. The character of the service seemed very much based upon the experiences and character of its chief. It has been pointed out elsewhere that "the residents are similar in social class characteristics to the (halfway house) managers... (alcoholism) services are organized on a socioeconomic basis."(2)

Methods of treatment, looked at across the forty facilities visited, are often contradictory. Several major treatment issues stand out as subjects of controversy: Fixed-length stay vs. indeterminate stays in treatment; insistence upon re-payment vs. subsidy for the patient; involuntary vs. voluntary commitments; sexual separation in residential facilities vs. sexual integration; insistence upon sobriety as a precondition of therapy vs. acceptance of still-drinking and inebriated clients. Ramifications for the design of facilities are as might be expected: contrary recommendations confound the researcher's efforts to establish facility guidelines. The contradictions go beyond details. Controversy includes debate over the merits of isolated inpatient facilities vs. local drop-in and outpatient services. The mix and emphasis in service directions is not uniform, even if all programs generally recognize the need for a full range of treatment elements.

It is impossible to decide which programs and environments are "appropriate" in light of current criteria. It is not clear what constitutes a demonstrably successful outcome of treatment. Most therapists objected to discussion of 'cures'. Even so, some indications of therapeutic progress are often felt necessary. Most frequently a lengthy period of sobriety—— usually a year—— and return to a 'normal' life of maintaining employment and family relationships are employed. Other programs accept shorter periods of sobriety and reduced costs of care. Criteria are by no means satisfactory to professionals in the field. For instance, there are no measures of effectiveness of preventive measures, or of impacts of programs upon communities to reduce the incidence of drinking problems. Sometimes the opposite effect occurs: when an alcoholism treatment service opens its doors, or advertises, an alcoholic population suddenly appears.

Even for the criteria based on sobriety, normal behavior, and fiscal measures, very few successes are claimed. It is often impossible to trace the personal and treatment history of a client to establish causal links that 'explain' remission. One clinician pointed out that clinical success rates are only slightly better than chance when compared against spontaneous remissions. Face-valid criteria such as membership in the AA justify the existence of the treatment institution, perhaps, but cannot be considered as measures of cures.

In the face of this bewildering information, one is prompted to ask what basic assumptions underlie the array of treatment facilities that make it possible to consider them all as members of the same class. Three common features of the alcoholism treatment enterprise are suggested by the existence of alcoholism-specific treatment facilities:

(a) Alcoholism, however it may be defined, is the primary phenomenon of concern. These services are all concerned with dealing with inappropriate drinking behaviors. Having drinking problems is the primary basis for accepting and providing services to clients.

(b) It is necessary to intervene in the lives of persons identified as alcoholics. This entails programs to change alcoholic behaviors to other behaviors, either sober behaviors or ones that bring drinking "under control". Intervention also implies the presence of two groups, staff and clients. The client may be an individual, a family, or a social group—— but the use of facilities as the seat of treatment generally focuses on the individual as the primary location of the origins of the drinking problem. If the client does not choose to come to the facility, the staff is not necessarily obligated to reach out to provide services. Motivation for treatment is thus important in determining who is served.

(c) Other caregivers (social services, health services, religious groups, etc.) are not primarily responsible for providing services to alcoholics. The alcoholic client is set apart as a subject of special concern. The implication is that other services are not fully capable of dealing with his problems, and that they have only limited responsibility for doing so.

These few common features say nothing about what the treatment facility should be like. The facility could be (and is) almost any type of facility, in almost any state of repair. In fact, most facilities in operation were not built for their current alcoholism treatment purposes. We agree with Cahn that the kind of facility an "alcoholic" will end up in is based more upon his socioeconomic status as an individual than upon a specific treatment appropriate for dealing with his condition as an alcoholic. This stands in marked contrast to people with medical problems, for instance, whose conditions are dealt with in the same kinds of facilities, in the same kinds of ways, regardless of their socioeconomic status.

Observation: The Facility as Limit

Drawing the relationship between physical space and therapeutic activities requires two kinds of information that are simply not available at the present time. A definitive relationship

> ...takes for granted the existence of a body of principles for treatment... that would permit the derivation of propositions about the nature of the 'atmosphere' and social interactions that should be induced by the... setting in order to maximize the therapeutic effects of the environment.(3)

additionally,

> ...the major problem... that continues to plague researchers in all of the behavioral science fields, is the absence of a conceptually adequate definition of the environment, not to mention a unified theory of the nature of the environment. To effect changes in behavior by modifying the physical setting requires just such a definition or theory.(4)

These remarks, initially directed towards problems of mental illness, apply equally well to problems of alcohol abuse.

As is clear from the protocol developed in the methodology, the researchers sought to establish definite ties between the therapy program and the physical environment in which it took place. Interviewing and site-visiting failed to establish a precise relationship, but they offered illumination.

When inhabitants of the treatment facilities were pressed to describe the uses and effects of the physical environment—— the bricks and mortar of the facility--- responses came in the area of physical functioning. Ambient temperature, freedom to move about, the appearance of surfaces, the availability of sanitary and gustatory conveniences--- replies covered this general area. There was little talk of the therapeutic relevance of physical space. Direct questioning on this subject initially produced strange looks and requests to repeat the question. The work of Hall (5), Sommer (6), and Spivak (7), and others is not generally known among practicing therapists.

In contrast, discussion of the therapeutic qualities of settings brought spontaneous and enthusiastic comments. "Settings" emerged over the course of the study as the medium of interaction between people—— the time, the place, the 'set' of the interaction. The setting is the product of all the elements that comprise the service: the administrative policies, the staffing pattern, funding constraints, regulations, the social milieu, the physical configuration. The setting is a mixture of both therapeutic and non-therapeutic factors. Staff and clients alike viewed the therapeutic quality of the treatment service in large part on the basis of the 'therapeutic potential' or the 'character' of the general settings available.

The suggestion here is that therapeutic exchanges are based primarily upon units of the individual and the institution from which he seeks service, rather than the traditional 'one-to-one' therapeutic relationship suggested by psychoanalytic theory.

Underlying clients' comments about therapeutic exchanges was the assumption that the facility and program are interdependent elements in the establishment of a service entity from which clients could legitimately and appropriately seek help for problems beyond their own immediate resources. Help was viewed as coming from the total setting, not solely through the walls, or only through things said by the therapists, or only through the social configuration of the treatment enterprise.

Staff comments about the therapeutic aspects of the service similarly expressed an interdependence between facilities and programs. The program invariably 'fits' the facility because (rightly or wrongly) it adapts to fit. Over time, the staff behaviors and the configuration of the program itself settle into an institutional "style" --- a pattern of institutional activities in an envelope established by the physical confines of the facility itself. Asking staff about the relationship of the building to the therapeutic enterprise is ultimately like asking a fish about the water he swims in. Yet staff were quick to point out shortcomings and strengths of other facilities and programs that provided backup for their own operations. Comments were often judgemental about the qualities of the space housing the neighboring program. The moral complexion of these comments was most often identical with the complexion of comments about the neighboring service itself. In fact, these comments seemed to be statements about the therapists' personal relationship to the 'set' of the neighboring service entity. It is understandable that a certain blindness might exist in their comments about their relation to their own service. Cahn points out that "personnel in a treatment situation tend to assume the dominant therapeutic ideology of their setting, despite background and training."(8)

Two unlooked-for observations follow from this view of the treatment enterprise as a service entity delivered through the complex "setting" medium. The first is that all clients get basically the same service. The second is that since the setting is the product of diverse, intricately interdependent elements, it is highly unlikely that any one person will completely understand the service entity. It is also the case that no one person or agency is fully responsible for it. The service entity is constantly changing as the elements comprising the setting themselves change--- and the changes are often not under control of the staff (that is, guided by therapeutic constraints). Often the changes are not directly accessible to cognitive recognition.

Our primary interest here is in the contribution of the physical environment to the service setting. That is, the 'interface' question concerning space's relevance to therapeutic concerns is one of the relationship between the physical environment and the treatment institution as it is reflected in the pattern of its settings. How is one to consider the physical environment in the establishment of the institution, particularly in light of the shortcomings of 'therapeutic' conceptions of program and of space-use?

For alcoholism treatment facilities, the physical environment is important as a limit establishing the boundaries of the treatment enterprise. As a limit, the building is both a barrier and an enabler. It is an inelastic limit that is not easily expanded or modified. It is a durable limit, one that lasts forever in comparison with the other elements that comprise a treatment service.

As a barrier, a facility includes some functions and excludes all others. A facility's human-biological-function provides a temperate environment and keeps out the weather. A facility's human-social-function provides for particular kinds of social groupings and filters out intrusions upon that group by outsiders. Generally, facilities have positive social functions--- they function primarily to support their in-group behavior. But they can have residual functions instead--- that is, their primary purpose can be to prevent certain kinds of social action from occurring outside their walls. Prisons serve this residual function; so do many alcoholism treatment facilities. The presumption underlying every treatment facility is that its primary purpose is socially positive, but it is perfectly clear that prisons and many other 'helping' institutions are in fact residual. Where corrective purposes cannot be carried out in a facility designed for correction, the facility functions as a residual social environment.

As an enabler, the physical environment structures behavior. This is obviously true at gross levels; people sleep in dormitories, eat in restaurants, study in classrooms. As this section's lead quotations indicate, we don't know much about the mechanisms by which facilities structure bahavior. Our power to predict and manipulate space to produce specific kindsof human interaction is presently limited. On a theoretical perspective, it is still quite limited. But on an experiential basis it can be considerable. It is possible to produce an environment that operates pretty much the way the clients, the users, and its surrounding community want, and even perhaps need, if they have a role in the design. The processes by which these user participations generate successful designs are often beyond researchers' analytical grasp, but the lucky accidents do occur. It is to be hoped that the resuscitation of the design process onto a disciplined footing will be able to integrate and expand the natural abilities of facility occupants that now tend to be discounted.

As both architectural researchers and practicing architects, the site-visit team contemplated the application of some of the newly developing design tools and conceptualizations of space-use to the problems of alcoholism treatment facility design. Yet it would be moving too hastily to consider design for alcoholism treatment facilities without first establishing the phenomenon of alcoholism treatment and its meanings in treatment facilities.

As an inelastic limit, the facility places unimpeachable drawstrings upon the responsibilities of alcoholism services. Limits are placed on responsibilities for the numbers of clients that must be seen, for locales that must be served, for the kinds of care that must be provided. A division of labor is encouraged between the various services; a clinic treatment setting obviously is not a residential treatment setting, but the presence of the one implies the need for the other.

As a *durable* limit, the facility provides resistance to change in the service's direction and development. Examples abound of facilities that continue to retard service activities beyond all reason. Ancient public hospitals in major cities are one good example; the procedural and financial and regulatory impediments to replacing or updating them require a greater quantum of energy than the public can muster. Additionally, the pattern of facilities--- their physical configuration--- produces modes of thought that are difficult to break. Architectural magazines that structure their reporting along "building types " categories embrace set social patterns as the basis for their coverage. Governing boards are notorious for their initial resistance to a replacement facility that represents a complete break with the old building's style and structuring of activities.

As a *resource limit*, the facility represents the careful husbanding of scarce resources. Facilities are good concentrators of resources--- staff can work with a maximum number of clients if the clients come to them, and staff can be resources to one another. Facilities also provide administrative benchmarks for setting the amount and type of services that must be supplied.

These latter limits act as sea-anchors in the growth and development of services. In large part, the facility's limiting function is based on the nature of the facility itself--- it is expensive, of durable materials, and requires considerable effort if major changes are to be made. But the facility can also be looked upon as a resource, and the community can be viewed as productive of facility resources. The fact that the facility is generally *not* a resource is due not only to the vagueness of the therapeutic underpinnings that nominally suggest its purpose. Facilities for the treatment enterprise are created in large part by non-therapeutic factors--- economic considerations, politics, requirements, laws, the structure of sanctioning agencies, health and safety and zoning codes. The influence of these non-therapeutic factors upon facilities for public services, will be the subject of the next section.

Observation: Four Non-Therapeutic Factors in the Production of Public Alcoholism Treatment Facilities

(1) Sanctioning and funding by public agencies are often different for the facility and for the program. Within HEW, for example, programs for community services are approved by the relevant program agency--- NIMH, Office of Education, Health Facilities Planning and Construction Service, etc. Construction and design review for these programs is handled by the Facilities Engineering and Construction Agency. The program staff do not have architects and others on their staff who are knowledgeable about the uses of space. Schematic design review--- review of the relationship between the proposed facility and the program goals and objectives--- takes place at the Federal level only on a haphazard basis, particularly since FECA is understaffed and legally committed to more construction-oriented aspects of the project. Most state agencies are structured similarly for handling public health, mental health, and mental retardation projects. Additionally, a "layered" approach to review--- approval by county agencies, state agencies, and Federal agencies, impedes the development of facilities to the point the facility is often obsolete when it opens its doors. In California, three years usually elapse between the time a Community Mental Health Center applicant initially requests construction assistance and the completed facility opens. For the last one or two years, the design is usually 'locked in.' Often the directorship of the CMHC has changed by the time the facility opens, and the new director is likely to have a completely different approach to the delivery of service.

(2) Funding and sanctioning agencies are structured to treat facilities as scarce resources. Public funding usually flows only when extreme need can be demonstrated, and flows again only in exceptional circumstances. Emphasis is often placed upon savings in the capital costs of construction. The FECA, for instance, is charged with reducing these costs to the extent possible. Regional Offices are required to submit periodic cost-saving reports. While this is important and sensible activity, the danger exists that genuine economies will be overlooked. Operational costs of health facilities, including salaries, are in the neighborhood of one-half of the initial construction costs. Inefficient design for use of staff can quickly wipe out construction savings. Inefficient program design can cost even more in the lost earnings of clients.

This situation is particularly troublesome for alcoholism treatment programs which are self-defining and change frequently. Several program directors have desired the use of pacilities as elements of program development in themselves. Governmental agencies are currently not organized to support use of public money in this way. The National Institute of Mental Health, for instance, still requires 50-year leases on land and 20-year use of facilities for mental health or closely related purposes.

(3) Codes, licensure, and regulations dictate design. Zoning codes are frequently interpreted to prevent the establishment of residential settings for alcoholics in residential neighborhoods, for instance. Life-safety codes (the National Fire Protection Association Code No. 101, for example) constrain open-plan mental health and alcoholism residential facility design. Insurance payments often are made only for care rendered in institutional-occupancy type facilities. These problems are well known and deserve mention here only because alcoholic and mentally ill populations often just don't fit the regulatory definitions of 'disabled' that determine the features and types of facilities used, and that determine the therapy that is provided.(9)

(4) Planning for services (facilities included) is based to a large extent on funding that is available. Comprehensive planning often looks to other comprehensive planning that has been funded and has achieved widespread notice among other planners and professionals. County-wide and larger governmental units often develop a master-plan for alcoholism services on the basis of other counties' and outside services' operations. Study of the area population to be served often consists of developing statistical data based on indicators used by other services. Planning tends to be at large scale, done without special study of at-risk populations, done in conformance with the regulations surrounding funding. The alcoholic consumer's participation in the development of comprehensive plans and master-plans for mental health is minimal, often non-existent. One wonders whether classification as alcoholics automatically bars service consumers from participation in the planning process, either directly or indirectly. It is hard to imagine "alcoholic" clientele participating in planning public services in the same way residents of San Francisco were invited to participate in the development of the city's urban design plan.(10)

Alcoholism Treatment Facilities: An Alternative Conception

The facilities we visited are not types unique to problems of alcohol. Addicts, criminals, the mentally ill, runaway adolescents, all share similar kinds of facilities. Halfway houses, supervised residences, clinics, emergency holding facilities—— these places host programs that deal with a variety of problems. Strong similarities exist between the institutions and treatment enterprises that deal with these groups.

The major role of these treatment institutions can be seen as the provision of living supports for their client populations. These populations have few places in straight society where they can live openly as alcoholics, addicts, etc. Taken collectively, these institutions establish the status of the individual and provide living supports on the basis of that status. 'Support' can come in many forms: certification for welfare subsidy, support through verbal exchanges, support for basic functional living prerequisites of food, clothing, and shelter. Inducing insights or behavioral changes to enable the individual to live outside these problematic populations——- the therapeutic enterprise——- are functions that are secondary to the primary function of support.

This point can be made another way. The disparity between conceptions of alcoholism, between programs' operations, and the sheer diversity of facilities, suggests that a consideration of alcoholism as a treatable entity is not the most profitable line to follow in understanding theuses of alcoholism treatment facilities. The basis for therapeutic programs is not clearly enough established. It is not possible to choose between even the differing conceptions. None, not even the current "disease" model, can claim success or distinguish clearly between means and ends.

The consequences for the architectural researcher are devastating. There is no way to classify the diverse facilities if such a line is followed. Viewing the physical environment across all facility-based programs as a counterpart to clinical programs is simply an impossible task. The state of the alcoholism treatment enterprise is too full of contradictions and paradoxes.

Yet it is possible to systematically and comprehensively order the different alcoholism-specific facilities if they, and the institutions that they shape, are conceptualized as mechanisms to support the living needs of their inhabitants. The facilities can be classified according to the degree and kinds of support they provide. Some provide complete living supports; others supply minimal supports. But they all provide some kind of support.

A continuum exists along which support is provided. The "continuum" is actually split into four quantum units, or levels of support. In turn, there seem to be four major classifications into which all facilities may be placed. From lesser to greater levels of support, these units are:

(1) Casual settings
(2) Clinic settings
(3) Residential settings
(4) Emergency settings

Casual settings are within the daily orbit of the client. The living rooms of Alcoholics Anonymous members are one example. Neighborhood drop-in centers and skid-row storefronts are another. These settings are available on demand, without scheduled appointments. They provide immediate support through contacts with people who are familiar with the client's situation, who can often help just by talking. Casual settings are also significant as contact points through which other kinds of support can be made available—— food, lodging, medical care, legal protection. The Traveler's Aid counter in railway stations is the counterpart casual setting for the travelling person.

Clinic settings provide more structured kinds of supports. Psychiatric services and medical services for ambulatory persons are examples. The medium of exchange is primarily verbal in these settings. The providers of support are expected to have special skills and techniques whereby the support can be efficiently provided in particularly helpful ways. Contacts tend to be brief and periodic. Scheduling is necessary to make 'efficient' use of staff. While some outreach activities may take place, clients are expected to initiate contact. Clinics provide another kind of support. The staff are authoritative agents who can legitimize the clients' status in ways that secure additional kinds of support, such as certifications for welfare payments and certifications to avoid jail.

Residential settings provide basic functional living needs: food, clothing, shelter, access to jobs, access to social contacts, access to other needed services. The arrangements under which these needs are provided vary greatly. The 'halfway house' is generally short-term (a few months) for relatively intact persons who are able to work, and who are able to pay for their support. The support is provided in the community. Hospitals and sanitoria provide for longer-term stays for persons, some not expected to pay. Often these facilities are located away from the communities their residents come from. It is in these residential facilities that one sees the bewildering variety of arrangements: sexually segregated units in some, sexually integrated units in others; locked doors in some, open doors in others; highly structured use of time with an elaborate structure of rewards in some, a loose, unregimented approach in others; fixed lengths of stay in some, indefinite stays in others. It is important to note that "alcoholics" have often done the loop in a dozen or more of these facilities.

The variety of arrangements is a source of amusement and anger to a person who's had wide experience. Amusement, in that the particular arrangements often held to be so important by staff are minor compared to the basic residential supports provided. Cause for anger, in that the particular arrangements are often demeaning and humiliating.

Emergency settings provide intensive support to deal with crisis situation. "Crisis situation" means a highly stressful situation requiring immediate action for resolution by some other person or group than is exhibiting crisis behavior. As Norman Sweet points out (11), the crisis is subject to definition by at least three parties: the subject in crisis; the agent providing crisis services, and the community that insists a crisis exists. Obviously, emergency settings are used in many ways that have little to do with the alcoholic's personal condition. Police 'sweeps' to clean up skid row following adverse newspaper coverage are crisis actions. From this perspective, a variety of facilities serve crisis functions. These include primarily the hospital emergency room, the city jail, the detoxification center, but might also include the clinician's office and the alcoholic's home.

We are able to show in the larger report being written for the National Institute of Alcoholism and Alcohol Abuse, NIMH, that the forty-odd treatment facilities visited can be unambiguously classified in terms of one or more of these support settings.

What are the implications of this perspective for the alcoholism treatment enterprise? Thinking in terms of settings suggests that many other facilities, locations, and situations than those contained within the alcoholism treatment facility network, might be appropriate for dealing with the functional needs and the needs for support that 'alcoholics' share with others. Alcoholism treatment facilities function as a network to support an ill-defined but observable group of people to whom the larger community is often inaccessible, and who are often unable to survive within an alcoholic subculture without subsidy. This function does not necessarily obviate the successful application of therapeutic techniques. Indeed, the most frequent justification for spending public money is that utilization of these support facilities will somehow enable the clients to return to the larger community with more acceptable behaviors. If the therapies are not demonstrably successful, the function of these facilities reverts from being one of assisting therapeutic progress to one of providing living supports for a group excluded from the larger community.

Conclusion: The Facility Tactic

The alcoholism treatment service housed apart from other programs in facilities accessible only to alcohol abusers is based on what might be called a "facility tactic". This approach isolates the alcoholic as a subject of special concern, requiring special treatment under the care of specially-trained therapists. This approach also isolates the client as a subject for special kinds of subsidy in the face of beyond-the-ordinary deprivations and rejections from other social groupings.

Special-purpose facilities are monuments to the appropriateness and legitimateness of this undertaking. The use of specialized facilities establishes social margin to cover conceptual and therapeutic softnesses in the treatment enterprise. Within the four walls, shortcomings are not so readily visible. Special facilities allow a concentration of staff and resources that permits treatment professionals to learn from each other and firmly establish the directions and scope of the service. The very presence of the facility gives notice that "something is being done" for a concerned community that does not deal effectively with drinking problems. The presence of the alcoholism-specific facility also givesnotice that other agents, other programs, are not fully responsible for dealing with alcoholism.

This approach is based on a disease model of providing human services. The 'ill person' is removed from the 'illness-producing' environment to specialized settings where specialized procedures are carried out that eliminate the malady. The premium is upon dealing with the disease rather than with the person as a human being. This model is applied to physical illness, mental illness, drug addiction, alcohol dependency--- it is at the root of our present approach to dealing with problematic social groups. The model's success is based upon success in dealing with the problem it defines. Clearly, if the problems are not well formulated, if cures are not known, if outcomes are not measureable, this model fails.

The model then becomes counter-productive. The place for successfully treating the disease becomes instead a place for indefinitely isolating the problem population. Cares of the day prevent devotion of effort to reconstituting the 'problem' and finding new solutions. The treatment service becomes instead a maintenance enterprise that perpetuates the problem's definition in the larger context of the surrounding community. The 'problem', removed from its context, becomes considered as an entity in itself by the community, the care-providers, and the clients. It is reified by the facilities employed to deal with it. The problem becomes a millstone, and the facility comes to serve a residual function.

If an approach based upon alcoholism-specific facilities is counter-productive, what is to be done about the observable excessive and destructive use of alcohol? No ready answers exist, but we suggest the thrust of future efforts must be to open existing treatment institutions and reverse the pattern of alcoholics' disenfranchisement from community environments. This suggests professional and community development rather than alcoholism-specific facilities.

Summary

Three major issues have been identified in the use of alcoholism-specific treatment facilities:

(1) The sheer diversity of facilities and disparities among their resident alcoholism programs suggest that the primary functions of these facilities, considered nationwide as a class, are something other than simply the treatment of alcoholism. An alternative conceptualization of these function, one that permits definition and classification of these facilities, considers them primarily as means of providing subsidies to persons disenfranchised from access to normal, more common means of support.

(2) The relationship between therapeutic activity and the use of space cannot rigorously established at the present time through theoretical models of the physical environment's relationship to social and psychological

behavior, even though there has been some considerable progress in this area. While the therapy program model may be established to the satisfaction of the therapists, it is still extremely difficult to translate therapeutic program requirements into designs of spaces that produce predictable behaviors.

The suggestion is made here that therapeutic exchanges, however therapy may be defined, are based upon settings. Within alcoholism-specific facilities, settings are extremely complex products of all the elements that comprise the alcoholism treatment service: administrative policies, funding constraints, local political and economic conditions, laws, governmental and other agencies' sanctioning regulations, treatment staff, clientele, the locale's social milieu, and the physical environment. It is suggested that settings are melds of these diverse factors; that the client perceives the setting as the entity from which he seeks service. Furthermore, settings structure therapists' activities, determining the kind and quality of therapeutic activities that take place. A conceptualization of the physical environment's role in the establishment of settings is that of establishing limits, both as barriers and enablers, on all the other elements that comprise the treatment service. The dimensions of physical environmental limits are suggested.

(3) The production of alcoholism-specific facilities does not presently permit their use as positive resources in the development of services. Sanctioning agencies, both public and private, are structured to treat the physical environment as a scarce resource. The effect of such a structure upon alcoholism services prevents or inhibits the self-defining and problem-solving activity necessary to improve therapeutic service to people. In fact, non-therapeutic factors in the production of alcholism-specific facilities raise questions about the validity of the therapeutic enterprise housed exclusively in such facilities.

These issues suggest that the alcoholism treatment enterprise centered within alcoholism-specific facilities, considered on a national scale, is most accurately conceptualized as functioning to maintain the current social isolation of alcoholics and as a system for providing various levels of life-support mainly to those alcoholics desiring to end their social isolation and alcoholic behavior. Since known therapies are most often of extremely limited success in helping drinkers successfully act on these desires, these facilities perform residual functions rather than transitional ones.

NOTES

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NOISE, DISTRACTION AND PRIVACY IN CONVENTIONAL AND OPEN SCHOOL ENVIRONMENTS

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Introduction

Open, unpartitioned space has been used to accommodate large numbers of workers engaged in similar tasks - secretarial pools, machine shops etc. - in business and industry for years. Recently, open office "landscaping" has been employed in business organizations to accommodate several departments or divisions (including professional, managerial, technical and clerical personnel) in common open work space in an effort to improve communication, work efficiency and reduce building costs.[1] Similarly, school building design practices have also employed "landscaping" approaches in recent years, creating what are commonly called "open-space" schools.[2] Rather than a series of classrooms of equal size arranged along corridors or vertically in various levels, the open-space school is composed of larger areas lacking interior partitions in which the visual and acoustical separation between teaching stations and classroom areas is limited or eliminated.

Attempts to rearrange the interior space of the school building into other than standard size classrooms have come about during a period in which theory and practice in both education and architecture have changed.[3] Most open-space schools have been planned on the basis of new requirements brought about by new curriculum materials and equipment, new student and staffing organization and new time allotments for instruction and planning.

A common picture brought to mind by the term "open" is a large loft area, unbroken by interior walls, occupied by several class groups and their teachers. Actually open-space schools vary widely in design characteristics. While space becomes increasingly open as square footage increases and the use of partitions decreases open space buildings range from those that make extensive use of flexible partition systems and are commonly referred to as "modified" open space to those that do not have any floor-to-ceiling partitions and are truly "open."

The first open-space schools were a handful of "experimental" buildings, constructed 9-10 years ago, consisting of instructional areas equivalent to two to four classrooms in size. These have largely been stereotypical as "larger" self-contained boxes." Newer schools have a wide range of design configurations and some have open instructional areas equivalent to over 30 classrooms in size[4]. Surveys have revealed that over 50% of all new schools constructed within the last four years have been of open design.[5]

The Problem

Combining several class groups and teachers in open instructional areas has created a more complex task environment as many diverse activities occur simultaneously in common space, than has been the case in conventional classrooms designed for one teacher and one class group. Efforts have been made to reduce the effects of acoustically incompatible activities through zoning, separation by low visual dividers, cooperative scheduling among teachers and tighter control of student behavior. A recent study has shown that background noise, speaker-to-listener distance, speech effort, barrier attenuation and speaker orientation are significant variables that can be controlled in both the design and modification of the acoustical environment to insure proper speech communication and privacy in open-space facilities.[6]

It is questionable, however, if adequate acoustical control can be achieved equally in open offices and schools. The task environment of the office is much less complex. Comparatively the density factor is 7-8 times greater in schools, most tasks depend largely upon complex verbal communication patterns that take place in various size groups, there is frequent change in the composition, size and location of task groups and many tasks are performed with the aid of audio-visual equipment.

The fact remains that noise reduction between class groups provided by floor-to-ceiling partitions in conventional classrooms is lowered considerably in unpartitioned open-space schools; thus, teachers and students are subjected to a wider range of potentially disruptive acoustical stimuli.

Claims and counter-claims have been made by critics and proponents regarding noise in open-space schools. Critics claim that high noise levels, high distraction, and reduced privacy have adverse effects upon students and teachers. On the other hand, proponents claim that excessive noise is eliminated through the use of carpeting and the constant background noise common in open space has a positive ubbering effect. Both sides readily cite ample anecdotal data - comments made by students and teachers - to support their arguments. There is, however, little systematic research data to indicate how noise affects teaching-learning activities or to what degree open space and conventional classrooms compare acoustically.

An extensive review of research comparing noise and task performance revealed few findings relevant to or generalizable to schools.[7] Most studies were highly controlled laboratory experiments utilizing subjects much older than elementary or high school students, employing tasks dissimilar to most learning tasks, or using distracting noise levels much higher than those normally found in schools. The presence of one or more of these factors in the studies cited make it impossible to draw definite conclusions about the relationship of noise and learning in school.

A survey of the acoustical environment of open and conventional classrooms was made when open-space planning was first employed in a small number of schools.[8] The "open" classrooms included in the study were simple modifications of conventional designs - classrooms not having doors, classrooms lacking corridor walls, or classrooms lacking separating walls. The five open classrooms lacking separating walls were approximately two equivalent classrooms in size, and of the 37 total classrooms in the study, only two were carpeted. Although noise measurements showed noise reduction to be generally lower in open rooms, noise levels were equal in open and conventional rooms. Staffing ratings of both types of rooms were also equal; most rooms were rated as "excellent" or "good." Those rooms receiving unacceptable ratings had severe acoustical defects.

Thus, in comparing open and conventional classrooms in 1963, acoustical measurements and staff ratings revealed few differences. It is questionalbe, however, to what degree these findings can be applied to contemporary open-space facilities. Further, little evidence has been obtained as to the effect of the open-space school upon the primary user - the student.

This paper focuses on the relationships between noise, distraction and privacy as perceived by students in open and conventional elementary and secondary schools. The effects of such factors as the nature of the educational program and classroom density upon student perceptions are also explored.

It is commonly assumed that high noise levels result in high distraction. Research has shown that this assumption is not commonly supported.[7] Several factors must be considered. First, the nature of the noise itself has different properties and is perceived differently; noise comes from many sources. Thus, different types of noise at the same intensity may have different effects. Secondly, not only are there different types of noise that may have disruptive effects, but there are also distracting factors not associated with noise, e.g., movement, crowding, temperature, etc. Third, the nature of the activity being performed may not require low noise levels for proper concentration. Fourth, perceptual levels vary with individuals. Thus, the first task was to determine to what extent noise levels were perceived differently by students in open and conventional space. The second task was to determine to what degree such factors as the type of educational program or classroom crowding (density) affect these relationships. Third was the task of investigating the noise-distraction relationship and to determine if students were distracted to a greater degree in open space. And a fourth task was to determine if open space results in reduced privacy for students.

Method

Sample

The elementary sample consisted of one-third of the 4th, 5th, and 6th grade boys and girls randomly selected from their home room groups in three schools - two open-space schools and one school with conventional classrooms. One of the open-space schools and the conventional schools were in the same school district. Both schools utilized the same basic curriculum and for the most part employed traditional teacher directed, group-based instructional methods. Although some teachers were in the process of encouraging greater student direction of learning activities, the programs in these schools were defined as conventional. The second open-space school employed a highly innovative program in which students were encouraged to work in small groups or individually without direct teacher supervision. Efforts were made to avoid whole class group instruction. As compared to the other two schools, the program was defined as individualized.

Both open-space schools were composed of instructional areas equivalent to four to six classrooms. Specific design configurations varied, however. All three schools were located in middle class suburban neighborhoods and served similar socio-economic populations.

The high school sample consisted of approximately one-third of all students in grades 9-12 enrolled in science courses in three suburban high schools in the same school district. In two schools an independent study program in all courses had been implemented. Students worked on study packets using reference materials and then completed laboratory exercises. Students were free to move between study centers and laboratories and worked both individually and in groups. Teachers worked with students upon request. In one school, the study area consisted of a large open area furnished with tables, study carrels, and bookcases. In the other students used conventional classrooms as study centers. Laboratories in both schools were of conventional design.

The program in the third school was conventional in nature. Teachers directed normal class groups in both study and laboratory activities.

Procedure

A 23-item questionnaire was administered to the elementary students as part of a larger research study concerned with several envirnmental variables including noise, distraction and privacy.

Similarly 65-item questionnaires were administered to the high school students as part of a larger study investigating the overall effects of the independent study programs. However, additional measures were employed in the open science department including the measurement of noise levels, temperature, and humidity, and structured observation of student behavior.

Results and Discussion

Noise and Distraction

Students in the three elementary schools were asked to indicate how often "your classes are too noisy" and how often "you are distracted in class." The percent of students in each school reporting their classes were too noisy and they were distracted "most of the time" are presented in Table I.

The data show that if the activity levels are held constant - the two schools with conventional programs - almost three times more students (56%) in conventional classrooms reported their classes as being too noisy most of the time as compared to 19% of the students in open space. However, 54% of the students in the second open-space school with a program marked by a high degree of small group interaction, the use of a variety of audio-visual equipment and constantly changing activity patterns and groupings reported it was too noisy most of the time. On-sight observations indicated that noise levels were higher in the open-space, individualized school; noise levels seemed to be about the same in the two schools with conventional programs. The "quality" of the acoustical environments, not the noise levels seemed to be the most important factor, however.

The hard surfaces of the tile floors and walls in the conventional classrooms created highly reverberant conditions which did not lessen the multiple effects of constantly generated scraping noises such as chairs and feet on the floor, banging noises such as dropped books and conversational noises. Carpeting and the lack of classroom walls in the opne-space schools created better reverberant conditions and eliminated many noises. The major source of noise was from conversations and created a general acoustical background for specific learning activities. Thus, much extraneous noise was eliminated in the open schools and minimized the potentially negative effects of the high noise levels in the individualized program.

Table I also shows that perceived high noise does not automatically result in distraction among students. Approximately one-half as many students reported being distracted most of the time as compared to those reporting class was too noisy most of the time. It is also noted that some students reported noise was a problem, but were not distracted while others reported being distracted but did not feel it

TABLE I
NOISE AND DISTRACTION AMONG
ELEMENTARY STUDENTS

	Individualized Program in Open Space (N=83)	Conventional Program in Open Space (N=67)	Conventional Program in Conventional Classrooms (N=74)
Class is too noisy most of the time	54%	19%	56%
Distracted most of the time	27%	9%	31%

TABLE II
SPECIFIC FACTORS CAUSING HIGH DISTRACTION AMONG ELEMENTARY STUDENTS

Distracting Factor	Open Space/Individualized Program (N=83)	Open Space/Conventional Program (N=67)	Conventional Space/Conventional Program (N=74)
General Noise	30%	19%	33%
Students Talking	54%	66%	50%
Student Movement	16%	15%	17%

was too noisy.

Further analysis of those factors students reported distracted them "most of the time" (presented in Table II) reveals that the talking of other students, not general noise, is most distracting in all three schools. The percentage distributions of students reporting general noise as most distracting are similar to the percentage distributions in Table I. However, the school having the lowest perceived noise levels and general distraction, the open-space school with the conventional program, had the largest percentage of students distracted most by the talking of other students. This could be expected in comparison with the conventional school; as noted above noise in the open school was primarily that caused by conversation while noise in the conventional school was caused by many other factors. In comparison to the second open-space school with the individualized program, the difference can be explained in part by student expectations and acclimation. There is considerably more student conversation, but students are freely allowed and encouraged to engage in small group discussion. They were also more accustomed to working in this type of environment than the students in the open-space school with the conventional program.

The low and approximately equal percent of students reporting they were distracted most by movement seems to show that neither the type of space (open-closed) or the type of program (individualized-conventional) had an effect. This is somewhat surprising in light of the precent of students who reported they felt there was too much movement in their classes: 38% in open space with individualized instruction, 19% in open-space with conventional instruction, and 43% in conventional classrooms with conventional instruction. It would appear that acoustical distractions are more influential than visual factors.

To further study the question of whether noise is more of a problem in open space, student perceptions of distraction were compared in a high noise generating independent study high school science program carried out in open space and conventional classrooms. Students were asked to indicate to what degree they were distracted by general noise and activity during non-laboratory activities and during laboratory activities. A third school with a conventional science program carried out in conventional classrooms was used as a control.

The percent of students reporting they were distracted "very much" by general noise and activity during both laboratory and non-laboratory activities is presented in Table III. Almost three times more students in the independent study program in open space and conventional classrooms were distracted to a high degree during non-laboratory activities than were students in conventional classrooms with a conventional program. This was expected because of basic differences in non-laboratory activities in the two programs. Non-laboratory activities in independent study consist of student-directed research and study which is carried out in groups with high interaction over 50% of the time. On the other hand, conventional non-laboratory activities consist of teacher lectures and demonstrations with very little student-directed activity or interaction.

The low percent of students reporting high distraction during laboratory work in all three schools was surprising, however, as laboratory

TABLE III
HIGH SCHOOL STUDENTS REPORTING HIGH DISTRACTION DURING TWO TYPES OF SCIENCE ACTIVITIES

Science Activities	Independent Study		Conventional Program
	Open Space (N=445)	Classrooms (N=332)	Classrooms (N=329)
Distraction during non-laboratory activities	26%	32%	11%
Distraction during laboratory activities	8%	14%	8%

TABLE IV
SPECIFIC FACTORS CAUSING DISTRACTION
DURING NON-LABORATORY ACTIVITIES

Distracting Factor	Independent Study Open Space (N=445)	 Classrooms (N=332)	Conventional Program Classrooms (N=329)
General Noise	22%	23%	7%
Presence of other students	15%	16%	10%
Student movement	10%	12%	5%
Student conversation - Science	9%	10%	12%
Student conversation - Social	29%	39%	24%

activities are largely student-directed, carried out in small groups, and marked by high interaction. Further, noise measurements averaged 65 dB in both the study center and laboratories in the open-space school. The low distraction during laboratory activities is attributed to basic differences in the two types of science activities, particularly in the independent study program. Laboratory work is largely task oriented, concerned with manipulation of equipment, while study activities require an extensive amount of reading and memorization using a high degree of concentration. It is noted that distraction was somewhat lower in open-space, lending support to the elementary findings and adding support to the notion that open space may be a superior acoustical environment.

Further analysis of the specific factors causing high distraction during non-laboratory activities is presented in Table IV. As expected the general noise level was a strong factor in the two independent study programs, but minor in the conventional program/conventional classroom school. This same relationship existed for two other factors that were also affected by the nature of the program - distraction caused by the presence of other students (density) and distraction by student movement; both schools with independent study had larger class sizes and unrestricted movement. However, distraction from the conversation of other students - both social and science-oriented - was not dependent upon the program and affected students about the same in all three schools, similarly to the elementary students. Social conversation was the factor creating the most distraction of all studied, with the largest percentage of students distracted in the conventional school with independent study.

Although the data show that acoustical factors seem to be most distracting, additional data from the open-space school point to a need for additional research. Students were asked to indicate to what degree they were distracted in the open-space science study center and a similar open-space facility - the social studies resource center. Activities in both were almost identical - a high amount of group interaction and work with reference materials. The noise levels in both areas were almost identical, ranging from 57-67 dB. The major difference in the two centers was the density - the science center was used as an assigned instructional space and provided 28 square feet per student, while the social studies center was used as supplementary space and provided 70 square feet per student. Consequently 31% of the students reported being distracted "very much" in the science center as compared to only 6% in the social studies center. Crowded conditions may amplify the effects of acoustical distractions, particularly if the major distracting factor is the social conversation of other students. Students may be able to cope with high noise levels if they can achieve greater physical separation.

Privacy

The open-space school has often been criticized because it affords students with little privacy. The elementary and high school data do not support this argument.

As a measure of personal privacy in the elementary schools studied, students were asked to indicate how often they were able to find an adequate place to study by themselves when needed. Over 50% of the students in the two open-space schools reported that they could find an adequate place "most of the time" as compared to 24% of the students in the conventional school. In considering the high noise

TABLE V
HIGH SCHOOL STUDENTS REPORTING INADEQUATE ACOUSTICAL
AND VISUAL PRIVACY DURING SCIENCE

Need	Independent Study Open Space (N=445)	 Classrooms (N=332)	Conventional Program Classrooms (N=329)
Acoustical Privacy	26%	29%	24%
Visual Privacy	27%	34%	40%

and distraction in the open-space school with the individualized program it would appear that distraction and privacy are independent factors. Further correlational analyses are needed.

The high school students were asked to indicate how often they were unable to find a quiet place for individual study and a place where they could not be seen by others - indicators of a need for acoustical and visual privacy respectively. The percent of students reporting they were unable to find either acoustical or visual privacy "almost all of the time" is presented in Table V.

Approximately one-quarter of the students in all three high school science programs indicated they did not have adequate acoustical privacy to do their work. It must be remembered that distraction from noise was over twice as great in the two independent study programs (see Tables III-IV). Fewer students in the open-space independent study program indicated a need for visual privacy as compared to the students in the two conventional schools. The students in the two independent study programs have considerably more personal choice as to where they could sit and also had a wider range of furniture to use including study carrels, particularly in the open study center. However, in comparing both open-space elementary and high schools with the conventional schools, the standard size classroom seems to provide students with far less opportunity to geographically separate themselves from their classmates; the lack of classroom boundaries in open space and additional common areas provide many more alternatives for choice of personal study space.

Summary

Contrary to popular criticisms, open space does not automatically result in higher noise and distraction or lower privacy as perceived by elementary and high school students. If program activity levels are held constant, open space may provide a superior acoustical environment through lowered reverberation conditions and the elimination of extraneous noise. This was particularly significant in comparing open and conventional elementary schools with conventional (low activity) programs.

A direct relationship between noise and distraction was not established. Analyses of specific distracting factors showed that "general noise" was not a good indicator as student perception was highly selective. Students were distracted most by student conversation - particularly social conversation. Furthermore, conversation was equally distracting in either open space or conventional space and in either high activity or low activity programs.

Differences in distraction were also found within general activity programs in the high schools studied. The differences between high and low activity programs were only significant for research and study activities; distraction was low and equal in laboratory activities.

Further analysis of two open-space study areas with equally high noise levels showed distraction to be significantly higher in the area with high density (crowded) conditions.

Open space provided students with greater privacy in both elementary and high schools with either high or low activity programs.

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DEVELOPMENT AND IMPLEMENTATION OF AN ENVIRONMENTAL EVALUATION AND REDESIGN PROCESS FOR A HIGH SCHOOL SCIENCE DEPARTMENT

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This paper examines the first year of activities of a project of environmental analysis and design being performed in the Science Department of Oak Grove High School, San Jose, California. This project is an attempt to develop a process by which environmental users may design, implement, and evaluate experiments in improving the fit of activities and environment to the tasks of teaching and learning.

Although this process is cyclical in the form described by James Boyce as "empirical evaluation" and shown diagrammatically in Figure 1 (1), this paper describes only the first phase. In this first phase the data base for future comparisons and for in use modifications to instructional programs and spaces was established. The cycling process is triggered whenever an experiment is prepared by the Science Department staff.

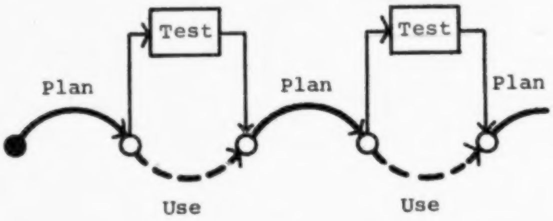


FIGURE 1. EMPIRICAL EVALUATION PROCESS

Background

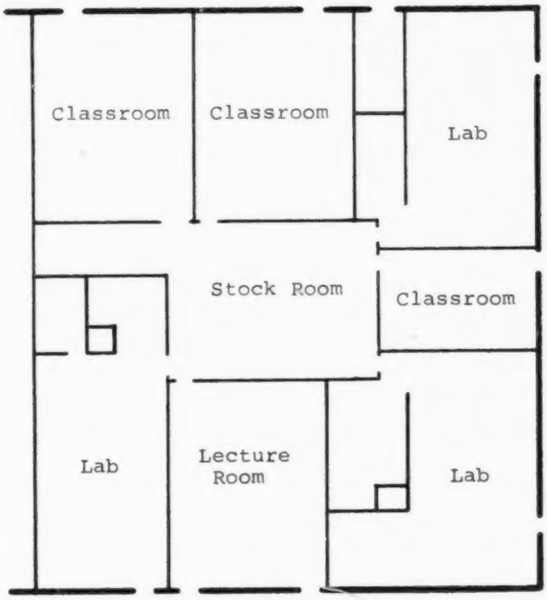
Oak Grove High School was one of ten secondary schools constructed under the School Construction Systems Development program (SCSD). SCSD, which was active from 1961 to 1967, developed an industrialized building system for use in school construction which provides flexibility in the physical components of buildings to respond to changes in educational programming and user needs (2). Oak Grove was designed by Allan M. Walter and Associates and placed in operation in September 1967.

In many areas of instruction, the school serves as a source of program and materials development for the Eastside Union High School District's nine schools. In this role, Oak Grove received a large grant from Kettering Foundation to develop and implement individualized instruction programs.

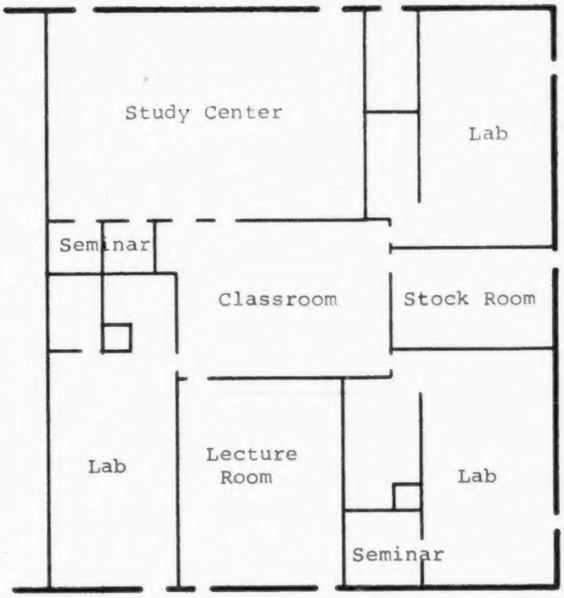
At Oak Grove, the teaching staff of the Science Department has been active in developing new curriculum and materials. This department began operations in a suite of classrooms and laboratories with a program calling for a conventional teacher-student relationship. In the past four years, the instructional program has been developed from this into an individual progress form of teaching with emphasis on the student as learner.

This evolution has required a rethinking of philosophy and roles, the development of new teaching materials, and the replanning of instructional spaces by the staff. The slow rate of materials development has paced this evolution in which two major spatial changes, corresponding to the completion of materials for freshman and for upperclass courses, have been made. These changes are illustrated in Figure 2.

While implementing these changes, the staff has constantly experimented with the spatial configuration and furniture layout of the suite, seeking better forms for their programs. At the completion of the development of the individual progress program, members of the staff felt that these experiments could be made more effective by application of a more formal methodology including better feedback.


Classroom
Classroom
Lab
Stock Room
Classroom
Lab
Lecture Room
Lab

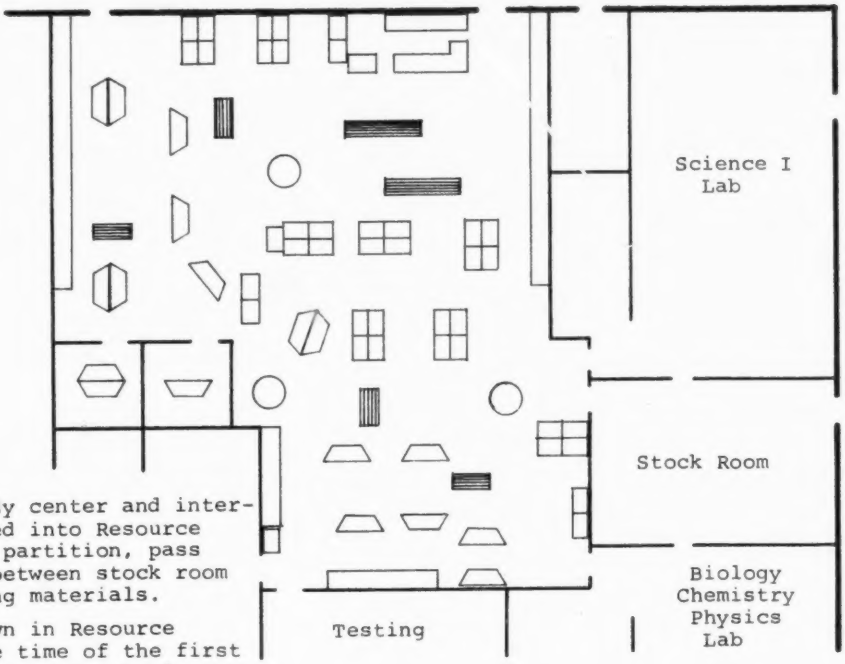
"Opening day plan" designed to house program of conventional teacher-student relationship.


Study Center
Lab
Seminar
Classroom
Stock Room
Lab
Lecture Room
Lab
Seminar

First changes: study center created by removing partition between two classrooms, three seminar or small group rooms made with parts of removed partition and doors.

FIGURE 2

SPATIAL CHANGES IN THE SUITE OF THE SCIENCE DEPARTMENT 1967-1971


Science I Lab
Stock Room
Testing
Biology Chemistry Physics Lab

Second changes: study center and interior classroom combined into Resource Center by removal of partition, pass through windows cut between stock room and labs for obtaining materials.

Furniture layout shown in Resource Center is that of the time of the first phase of the Oak Grove High School Research Project.

Oak Grove High School Research Project

In the fall of 1970, the science department teaching staff approached the Building Systems Information Clearinghouse and the School Planning Laboratory of Stanford University with a request for assistance in gathering the data necessary to evaluate their programmatic and spatial experiments.

At that time, both of these organizations were involved in projects which related to the needs of the Oak Grove staff. The Building Systems Information Clearinghouse (BSIC), itself an outgrowth of the SCSD program, had been engaged in an evaluation of user response to the SCSD schools in 1969 and 1970. A group from the School Planning Laboratory (SPL) had been involved in a study of the effect of open space planning and programming upon the behavior and attitudes of teachers and students.

In October 1970, a group consisting of Mr. Arvel Clark, principal of Oak Grove High School, Mr. Jack Grube, co-chairman of the Science Department, Dr.Frank Brunetti of SPL, and Dr. John R. Boice and Mr. Joshua A. Burns of BSIC began meeting to develop the project. The study was christened the "Oak Grove High School Research Project."

As the project developed, these organizations were able to obtain the assistance and participation of other groups in various aspects of the study. To the present, a number of such groups have participated, including the Stanford Center for Research and Development in Teaching, the First California Commission on School Construction Systems, San Jose State College, and Lennox Industries.

Underlying Assumptions

Before proceeding to a discussion of the development of the project, some of the underlying assumptions should be made explicit. These assumptions were largely shared by the teaching staff and the study groups in the program. Although not formally stated during project development, they appeared often during the discussions of this period.

Underlying the entire study process is an assumption that a school is a "system"--composed of buildings, programs, materials, teachers, students, and other elements--the objective of which is the delivery of "education". In the functioning of this educational system, the interaction of elements may be of equal or greater significance than the elements themselves.

Likewise, the total environment in which learning takes place is composed of a great many interrelated elements--students, educational materials, environmental conditions, attitudes, teachers, and spaces to name a few. While each of these elements, and elements of each, may be studied independently, it is the totality of their interaction which creates the environment.

When the school is conceived as a system, it becomes clear that the school will be expected to respond to changes in both its external environment and in the elements or subsystems which compose the system. In this view, a school and its subsystems can be seen as a set of experiments working themselves out. The structure of the study is based upon this view of the school as an on-going experiment expressed by the teaching staff of the science department.

Objectives and Methodology

The original request made by the Science Department staff stated the problem with sufficient clarity to serve as the basic statement of project objectives. In this request, the staff sought to create a group which would collect data about environmental and behavioral conditions before and after the implementation of "experiments" in manipulating these conditions designed by the teaching staff.

In response to the project objectives, a methodology was developed which could be applied whenever the teaching staff was prepared for an experiment. The basic procedures of this methodology are:

(1) Statement of the objectives of the experiment by teaching staff; in the first phase, this consisted of a statement of the objectives of the Science Department's educational program.

(2) Conversion of these program objectives into measurable behavioral objectives.

(3) Measurement, observation, and survey.

(4) Analysis of this data including comparison of anticipated versus observed system behavior.

(5) Synthesis of results into (a) decisions about the experiment and/or (b) design criteria for program and spatial improvements.

(6) Implementation of action defined in (5).

(7) Iteration of steps (1) to (6) for each experiment.

Establishing a Data Base

In order to have a sound basis for evaluating future experiments, it was decided that the first iteration of these procedures would be the formation of a data base on existing environmental conditions, activity patterns and user attitudes in the Science Department. At the end of this process, in steps (5) and (6) above, alterations and corrections to improve the functioning of the Department would be made.

In February and March 1971, an intensive two week long series of measurements and observations were made in the department suite. These studies were followed up by surveys of students both at Oak Grove and at other high schools in the district. Following a brief discussion of the operations of the department at the time of the study, the key findings of these studies will be presented.

Department Operations

At the time of the study, the Science Department was housed in the suite illustrated in Figure 2. The heart of this suite, and the area of concentration for the study, was the Science Resource Center, a large open room in which most science related activities took place.

The department operated on a six period day with each period averaging fifty-five minutes in length. The average number of students in attendance in the department at the time of the study was 177 per period. Of this number, an average of 40 were in the two main labs and an average of 137 in the Resource Center.

The staff consisted of six certified teachers and three paraprofessionals who handled mechanical chores of the program, such as maintaining the library, distributing materials, taking attendance, etc. The schedule was organized so that five teachers were on duty in each period, one in each laboratory and three in the Resource Center.

Measuring Environmental Conditions

In the data base phase, measurement of existing environmental conditions was limited to three variables: noise levels, thermal environment conditions, and lighting levels.

The level of noise within the rooms of the department suite was measured by Bolt, Beranek, and Newman, Inc., Acoustic Engineers, on March 2, 1971. The results of these measurements for a typical class period in the Resource Center are presented on Figure 3. Figure 4 compares the noise level in the science department with that in other spaces in the school.

The results of these studies indicated that the noise levels in the Resource Center and the two laboratories were similar and, in both cases, of a level sufficient to be considered a major problem. The recommendation for improving conditions by this consultant was that the noise level problem could only be effectively reduced by a combination of improved room absorption and more effective teacher control of noise generation.

Thermal environment and lighting conditions in the Resource Center were found to be inadequate due to a failure by the school to change their configuration when the two spatial changes were made in the departmental suite (see Figure 2). The air-conditioning system while maintaining temperature within designed limits, had inadequate air movement patterns and the treated air had a very low relative humidity.

The lighting system was found to be potentially capable of providing required illumination levels throughout the Resource Center but was configured in an ineffective manner for the space use pattern. For both systems reconfiguration of fixtures was recommended. An alternative suggestion for the lighting system was to alter space use patterns to make better use of the existing lighting conditions.

With the exception of the noise level

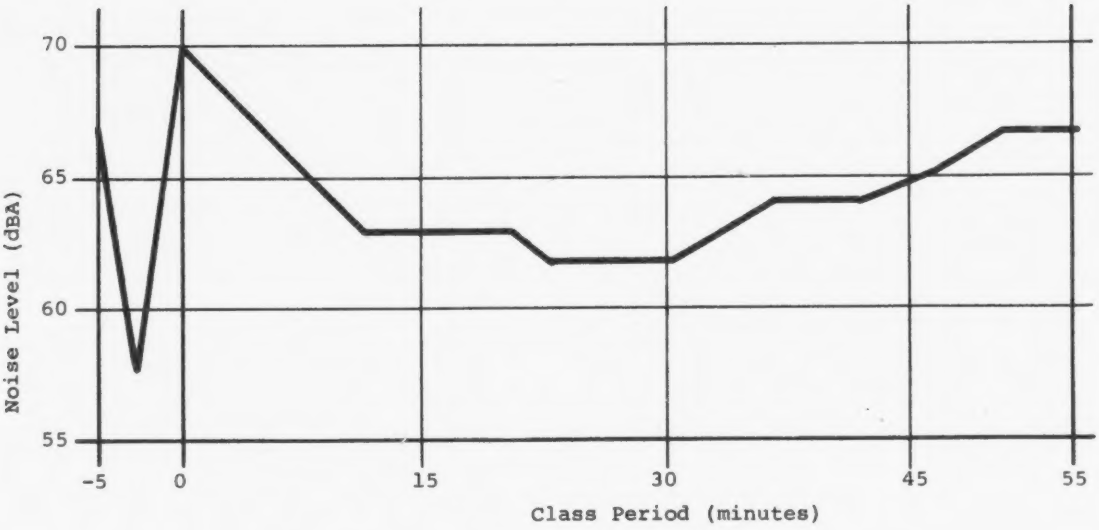


FIGURE 3

NOISE LEVEL IN RESOURCE CENTER DURING TYPICAL CLASS PERIOD

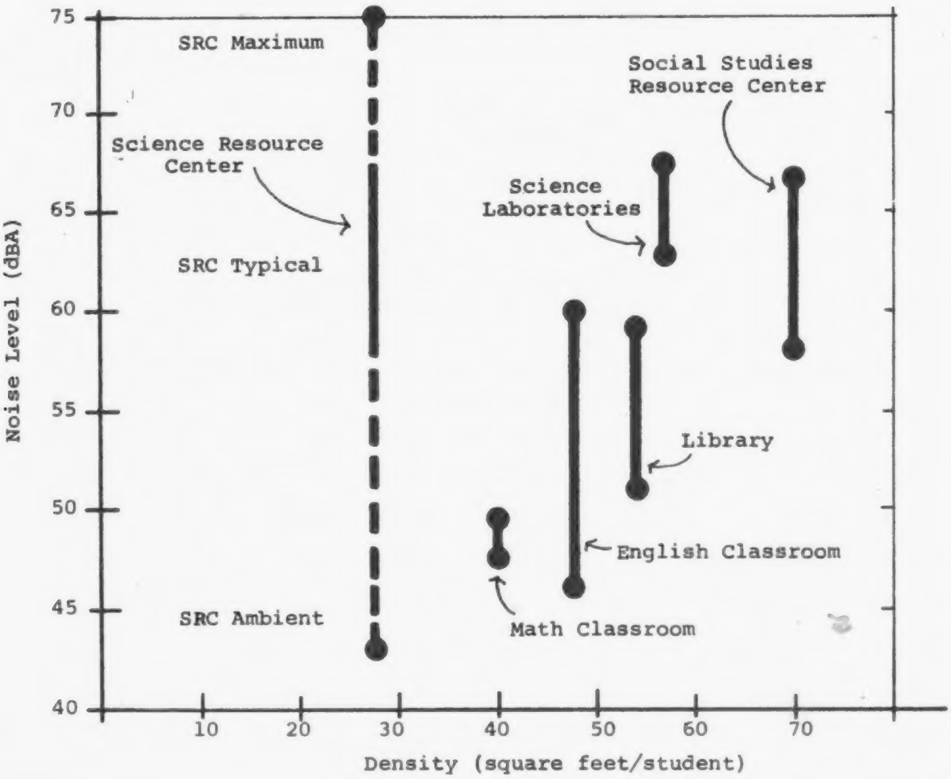


FIGURE 4

NOISE LEVELS AND DENSITIES IN VARIOUS SPACES problems, environmental conditions in the laboratories appeared to be adequate. These spaces had not been altered in either of the two spatial changes and the use patterns were essentially the same as at the time of school opening.

Behavioral Studies

During the two week period of studies, a group of graduate students in education from Stanford University and San Jose State College led by Dr. Frank Brunetti made a series of mapping and observational studies. This group developed its observational format from a written statement of educational program objectives prepared by the department staff.

Emphasis in this program was on observing, recording and mapping grouping patterns and the types of activities engaged in by groups and individuals. The scope of the study included the Resource Center and the two laboratories. During the study, major furniture elements were fixed in location while chairs, etc., were allowed to be freely moved by students.

Both in this section and the following section on attitudes, a selection from the data gathered will be presented. The selection from behavioral data covers activities, group patterns, and the relationship between the two. While a great deal more data was gathered, these facets proved to be the most important in the data base phase of the study.

The observation group developed an activity coding used in mapping of seven activity categories which are listed on Table I. In analysing the results of activity mapping, the class period was divided into thirds. Table I presents the results for the Science Resource Center for the two laboratories combined.

A study of this table indicates that there is a much higher incidence of relevant (science oriented) activity in the two laboratories and that all activities in the labs are more stable throughout the period. A combination of factors -- greater direction of task, more teacher supervision, preference for manual tasks, and others -- probably influence this distinction.

Although the program is defined as individual progress, the majority of students observed worked in groups rather than alone, see Table II. Over time, the individuals and groups of two tended to be more stable in their relevant activity than did larger groups.

Attitudinal Studies

Dr. Brunetti's group also prepared and administered an "opinionaire" survey of student attitudes towards aspects of

TABLE I

PERCENTAGE OF STUDENTS ENGAGED IN
VARIOUS ACTIVITIES DURING CLASS PERIOD

	Science Resource Center				Two Laboratories			
	Third of Period			Net	Third of Period			Net
Activity	1st	2nd	3rd	Change*	1st	2nd	3rd	Change*
Science Tasks	57.0%	54.6%	43.2%	-13.8%	75.3%	68.9%	72.3%	- 3.0%
Social Interaction	26.0	29.6	38.5	+12.5	7.2	14.3	13.6	+ 6.4
Teacher Interaction	4.0	3.7	2.8	- 1.2	4.9	6.9	2.8	- 2.1
Idle	5.1	4.4	6.9	+ 1.8	6.0	5.0	5.0	- 1.0
Other Subjects	3.3	3.4	3.9	+ 0.6	1.4	1.4	1.5	+ 0.1
Movement	4.6	4.3	3.9	- 0.7	5.2	3.6	5.6	+ 0.4

*Net Change = (Percentage in final third) - (Percentage in first third)

TABLE II

PERCENTAGE OF STUDENTS INVOLVED IN
INDIVIDUAL AND GROUP ACTIVITIES
AND MOVEMENT

Activity	Resource Center	Labs
Individual	42.3%	40.7%
Group	52.6	55.0
Movement	5.1	4.3

the program and the environment in the school and the Science Department. For purposes of comparison, the opinionaire was also administered at other high schools in the districts, the results have been presented elsewhere (3).

The problem of student distraction is a key issue in the study of open plan learning environments. At Oak Grove, more students (57.6 per cent) reported a high degree of distraction in the Science Resource Center than in either the labs (22.7 per cent) or in two spaces in the school which have similar open plans and programs: the Library (17.5 per cent) and the Social Studies Resource Center (17.6 per cent).

Table III presents student response on distracting factors in the Science Resource Center and the labs. A comparison of noise levels and student density (area per student) in these spaces is presented in Figure 4.

The study results have provided some insights into the problem of distraction in open space at Oak Grove. The results indicate that the type of activity causing the distraction and the activities of the respondent are closely related to the feeling of distraction. In addition, a relationship between student density and the amount of distraction due to noise levels has been observed.

Feedback

The data base formation phase of the study had two objectives: to establish the data base and to develop feedback upon which corrections and improvements in space and activities could be based. As a result, data analysis resulted in the development of criteria for modifying the instructional spaces and the activities of teachers and students.

A number of improvements were identified which were felt to be necessary for more effective functioning of the educational program. Briefly stated these modifications included improvement in environmental conditions, especially reduction of noise levels, greater control of grouping patterns and activities of students, and greater student-teacher interaction.

Financial considerations forced the postponement of three changes felt to be desirable: increasing room sound absorption in the Resource Center and labs, obtaining furnishings which would help control the size of groups, and developing moveable space dividers to provide a greater variety of spatial conditions. These modifications have been studied in detail and will be implemented as funds become available.

Making changes

In most cases, the recommended improvements in conditions required a combination of spatial alteration and increased teacher activity. Discussions between the staff and the study team of the results of the data base phase led to an understanding of what could be expected from various alterations and to a commitment by the staff to work with both space and their activities.

TABLE III

PERCENTAGE OF STUDENTS INDICATING
A HIGH DEGREE OF DISTRACTION
DUE TO SEVERAL FACTORS

Distraction Factor	Resource Center	Labs
General noise level	48.3%	23.4%
Presence of other students	36.4	24.1
Movement of other students	23.5	17.7
Conversation of other students working on science	24.2	16.2
Social conversation of other students	55.9	37.7

Spatial redesign was performed using a large scale model of the Resource Center and available furnishings prepared by BSIC. An afternoon was set aside upon which the staff and the consultants came together to design the new layout.

The teaching staff worked with the models to express various design ideas. The consultants evaluated the evolving designs which were periodically recorded with a Polaroid camera. Eventually a design satisfactory to the staff was achieved and implemented in the Resource Center.

Since implementing this redesign, the teachers have been increasing their interaction with the students. At the time of the first phase, the teaching staff had been intentionally keeping interaction at a minimum in order to assess the effects of the individual progress program and materials.

At the completion of the study the teachers agreed that a relatively high level of teacher/student interaction is necessary for the program to work at its best. In this respect, the findings of the study not only reinforced their feelings, but gave them valuable assistance in defining their new roles.

Conclusions

(1) The project appears to have been successful in achieving its objective of providing useable data to the Science Department staff.

(2) Working with the project has increased the teachers understanding of what goes on in the Science Department. One result of this is greater teacher confidence in guiding and controlling group formation and other student activities. A second result is an improved ability to communicate their goals and objectives in terms of what they desire to see happening (4).

(3) A number of factors which may affect the situation have been identified for further study, including long and short term effects of environmental conditions, the actual and the general problem of morale.

(4) In spite of the progress towards individualized instruction, the options available to the student and the teacher are still limited. The instructional spaces are sufficiently crowded to make selection of activities within the class period of the "musical chairs" variety. A student assigned to the Science Department during a class period must be present and under science teacher supervision. Finally, and justifiably in the light of the problems of curriculum development with a limited staff and resources, there are no real options except rate of progress in the instructional program.

(5) While scientifically sound, current methods of environmental and behavioral analysis are difficult to apply, expensive, and produce results which may be too precise for their purpose. New tools oriented toward quick and easy application and analysis must be developed.

(6) Current school budgeting procedures do not allow the tuning-up of a building when it opens nor do they permit evolution of spaces and environmental conditions.

Summary

The Oak Grove High School Research Project was undertaken in the fall of 1970 to provide the staff of the school's Science Department with better data for evaluating experiments designed to improve their program, activities, and instructional spaces.

In the year since the study was undertaken, the project has completed slightly more than one cycle of activities. A data base for evaluating future experiments has been formed. In addition the data collected in this phase has been used to evaluate behavioral and environmental aspects of the instructional program. As a result of this evaluation, improvements have been designed and implemented in both of these components of the educational system.

The assumption underlying this work has been that the school is a continually evolving set of experiments. By applying a more formal method, these experiments can be directed and harnessed to provide greater improvement in the school's role as a system delivering education.

Notes

(1) Boyce, James R., "What is the Systems Approach?", Progressive Architecture, November, 1969.

(2) Boice, John R., A History and Evaluation of the SCSD Project, 1961-1967, 1971.

(3) Brunetti, Dr. Frank, "Open Space: A Status Report", CEFP Journal, October, 1971.

(4) Burns, Joshua A., Memo on meeting with Mr. Jack Grube, co-chairman of the Science Department at Oak Grove High School, (unpublished), November 4, 1971.

OBSERVATION OF USER ACTIVITY PATTERNS IN OPEN AND TRADITIONAL PLAN SCHOOL ENVIRONMENTS

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Abstract

Do the activities of teachers and students in flexible space differ from the activities of teachers and students in traditional space? The paper reports the results from an observation technique used to explore this question. It is part of a larger project evaluating the open building systems project of the Study of Educational Facilities of the Metropolitan Toronto School Board. This report deals with 2,900 observations of classrooms, teaching areas, kindergartens, libraries, and commons in twelve schools (four traditional plan schools, four open plan schools and four SEF schools). The observers recorded the number of people in the spaces, the kinds of groupings, the activities, the amount of movement, and the number of different types of tools being used. The results show that the activity patterns in open plan schools are quite distinct from traditional plan schools. On the whole, there is less structuring of spaces, teachers are more personal and informal with the students. Students work more often in small groups or alone and use a greater variety of tools. Differences in activity patterns were related to the socio-economic status of the district and to the size of the schools. While part of the differences measured may be due to self-selection of teachers or a simple Hawthorne effect, some seems attributable to the nature of the physical space. Future extension of the study will attempt to establish relationships between activity patterns and behavioural outcomes.

Do the activities of teachers and students in flexible space differ from the activities of teachers and students in traditional space? How does the distribution of users in a space affect the way in which the space is used? Little empirical evidence is available to answer questions such as these.

A review of the literature showed that there have been many articles written on open plan schools and open style teaching which were pithy and discursive, but there are very few well thought out empirical studies (1). At the same time there are over a hundred observation instruments which have been used in classrooms, but the majority of these are concerned with the interaction among a small number of people, have very complex and elaborate coding schemes and have a very narrow range of generalizability (2). The only research that appeared useful from a theoretical and methodological point of view was the behavioural mapping research of Proshansky, Ittelson and Rivlin, but their reported results at the time of this study were concerned only with the behaviour of individuals rather than groups (3).

In general terms, the problem was to learn about the activities of all the humans in a building and to contrast this with the activities of other humans in other buildings. Since there appeared to be no developed theory or tested methodology to study such a complex issue the decision was made that it would be wisest to proceed on the broadest possible front with the simplest possible instruments and to rely on analyses that "rang truest" in terms of everyday human experience.

Therefore, the task was to identify those physical consequences or artifacts of activity whose presence or absence would be instantly measurable by relatively naive observers.

Another requirement was that the items had to have face validity. For instance, the number of discernably distinct noises appeared to result directly from the ongoing activities and the number of visually distinct groupings or clusters of people also appeared related to the variety of activities in a space. Also, the proximity of humans to one another and facial indications of pleasure or tension indexed to some extent the social tone or climate of an interaction.

The plan was to record precisely a number of these readily observable features of activity over a large number of spaces throughout the school over an extended time period. It was hoped that by "skimming" the school environment visually many times and in many places with human observers, it would be possible to capture some flavour of what was "going on" as well as an exact measure of how much was happening. An attempt was also made to develop an instrument which discriminated open style teaching from conventional teaching without regard to the subject being taught, the age level of the students, or the type of physical facility.

The report we are presenting here is part of a larger evaluation study of schools built by the Study of Educational Facilities (SEF) of the Metropolitan Toronto School Board, (4). SEF is now completing the first major open system project in Canada. More than 25 SEF schools are already in use in North America.

Sample

After a review of the literature and discussions with teachers, students, educators and other professionals, it was decided that the first year baseline study would include only junior elementary (K-6) schools. In addition to the four SEF schools chosen for this phase of the study, four open plan schools and four traditional plan schools were selected. Throughout this report, Non-SEF open plan schools are designated as NSO schools and non-SEF traditional plan schools are designated as NST schools. The four SEF schools were matched as closely as possible with the eight non-SEF schools on the basis of geographical proximity, size of student body, and the general demographic status of the neighbourhood. The SEF building system does not dictate open space, but the six local boards of education in Metro Toronto designed their SEF schools with open space of varying degrees.

Instrumentation

A form was developed for recording direct observations in schools. Prior to the actual pretest many class areas were observed in both SEF and non-SEF schools and informal discussions held with principals, teachers, and students. In addition, trial and error experimentation with various kinds of observational approaches lead to a method which allowed the observers to note unobtrusively how various kinds of space were being used by different people at different times.

Observers

The observers were either experienced teachers and/or interviewers. The same observers were used in the pretest and the formal test and were trained in several day-long sessions prior to and after the pretest. The observers were instructed to be friendly with the teachers and students, but to avoid direct involvement in school activities.

Several safeguards were built into the observation procedures to counteract observer bias. First, the observers were employees of a commercial research firm and not a school board. Second, the need for objectivity was stressed to the observers. Furthermore, the purpose of some of the questions was disguised and the observers alternated across different types of schools. Finally, spot checks were made on the observers.

Data Collection

Data was collected between mid April and mid May, 1971. Each of seven observers observed in several types of schools to control interviewer bias. Generally two observers made three independent cycles to 20 spaces in each school each day for a week. Each cycle followed a different route so that a picture of the total activity of the school was obtained. The observers recorded the number of people in the spaces, the kinds of groupings, the activities, the amount of movement and the number of tools being used. From these observations three main aspects of activity were derived: the general structure of the area; the teaching style; and the activities of the students. These three items were then combined in the analysis to gain an overall view of the activity patterns in each type of school.

In addition, observations were made of the dispersion of people in the spaces. This included such measures as the number of students in a space, the number of groups in a space, and the number of students working alone.

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In addition, observations were made of the dispersion of people in the spaces. This included such measures as the number of students in a space, the number of groups in a space, and the number of students working alone.

A shortened form was used for administrative areas, seminar rooms, and other special facilities such as the music room or gym. It should be emphasized that this report deals only with the results from 2,900 observations of general teaching areas, kindergartens, libraries, and commons, and excludes the data from other specialized areas.

General Structure of Area

The observers first looked at the arrangement of the furniture in the space. A space was judged to have had high definition if the furniture was set up in a very definite and organized pattern. This would occur in a space where student desks were arranged neatly in rows with the teacher's desk at the front, or where students' chairs were arranged in a formal semicircle around a teacher.

A space had low definition if the furniture was scattered around the room with little apparent pattern. Finally, a room in which some of the furniture was organized and the rest of it scattered was labelled combination.

A comparison of the types of schools showed that the SEF schools had the highest percentage of low definition spaces (38.1 percent), the NSO schools the highest percentage of spaces designated "combination" (68.5 percent) and the NST schools the highest percentage of high definition spaces (33.9 percent).

The observers also recorded the number of focal points in each space. For example, if an observer in a space saw one group of students looking at some rabbits, another group watching a TV program, and a third group working with a teacher at a flipboard, the observer would record three focal points for that space. If all the students were working independently and the teacher was walking about, this would be recorded as zero focal points

In the SEF schools, over half the time (53.1 percent of the observations) there were several focal points in a space, while in the NSO and NST schools, the observers reported several focal points in a space about one-third of the time (32.9 percent and 31.1 percent repectively).

The answers recorded on the furniture arrangement of and the focal points in the room were combined into a scale of structure. If a space had high definition and one focal point, it would be indexed as high structure; conversely, if the space had low definition and several focal points, it would result in a low structure score.

Table 1: Scale of Structure by Type of School (5)

Type of School	Structure High %	 Medium %	 Low %	N
SEF	35.0	42.2	22.7	1051
NSO	49.2	44.0	6.9	846
NST	57.8	29.6	12.6	1003

Table 1 indicates that the SEF schools had the highest percentage of spaces with low structure scores (22.7 percent) and the NST school had the highest percentage of spaces with high structure (57.8 percent). The NSO school had the smallest percentage of spaces with low structure scores (6.9 percent).

In addition to differences among school types, the scale of structure varied with the socio-economic status of the neighborhood and with the size of the school. Schools which were in low socio-economic districts had a higher percentage of spaces with low structure and medium structure (18.2 percent and 41.9 percent respectively) than the schools in higher socio-economic areas. Schools in medium socio-economic areas had the highest percentage of highly structured spaces. On the other hand, the larger schools had a higher percentage of spaces with low structure than did the medium and smaller schools. The latter were most likely to have highly structured spaces.

Teaching Style

When an adult was in a room, the observers scored the adult as either being engaged or not engaged with students. To be scored as "engaged", an adult had to be talking with and/or listening to students. If the adult was observing students, talking with another adult or working alone, the adult was scored "not engaged."

A somewhat larger percentage of the adults in SEF schools were scored as engaged (77.0 percent) than in the NSO and NST schools (73.9 percent and 69.6 percent). The differences were statistically significant, but numerically small.

A situation was rated formal if the adult appeared tense, informal if the adult appeared relaxed, and neutral if the observer could not sense either tension or informality. The highest percentage of informal situations were found in the SEF schools (55.0 percent) and the highest percentage of formal in the NST schools (19.9 percent). The NSO schools had the highest proportion of neutral scores (48.4 percent).

The observers also recorded the adults' physical position in relation to students. If, for example, the adult was bending down to a child or kneeling beside a child, the situation was scored personal. If the adult was close enough to touch a student or was formally helping a student with no physical barriers between them, the situation was scored conventional. Finally, if the adult was at a blackboard, behind a desk, or beyond touching distance of the children, the situation was scored distant.

Approximately 43 percent of the situations in all types of schools were scored conventional. However 29.1 percent were scored personal in SEF schools, compared with 19.0 percent in the NST schools and 13.2 percent in the NSO schools.

A scale of the style of teaching was developed by combining the engagement or non-engagement of the adult, the formality or informality of the situation, and the adults' position in relation to the students. A high style indicated that the teacher was not engaged, and was formal and distant in relation to the children. A low style score resulted when the teacher was engaged with the students, appeared relaxed, and was within personal distance of the students. A medium score resulted when a teacher was engaged but where the social atmosphere was neutral and the teacher was sitting with a group.

Table 2: Scale of Teaching Style by Type of School

	Scale of Style			
Type of School	High %	Medium %	Low %	N
SEF	11.1	44.5	44.5	893
NSO	18.9	53.5	27.7	636
NST	22.4	48.6	29.0	942

The results in Table 2 indicate that the highest percentage of adults with low style scores was in the SEF schools (44.5 percent), the highest percentage of medium style scores was in the NSO schools (53.5 percent), and the highest percentage of high style scores was in the NST schools (22.4 percent).

Schools which were large in size and in low socio-economic districts had a higher percentage of low style scores. Schools in the high socio-economic districts and schools small in size tended to have the smallest percentage of low style scores.

Activities of the Students

The observers next recorded the movement of people in the space. The amount of movement was rated none if no students were walking, or if only one adult or student was walking. If there were two to five people walking about, movement was scored moderate. Where more than five people were walking about a space, movement was scored as considerable.

Across all schools, the observers found considerable movement in 9.5 percent of the situations. However, in 50.5 percent of the spaces in SEF schools, there was moderate movement. This compared with 36.0 percent in the NSO schools and 31.9 percent in the NST schools.

The variety of tools being used by the students is also a measure of activity. All tools were divided into six categories as follows:

- Fixed Marking and Reading: chalkboard, display or bulletin boards.
- Portable Marking and Reading: all books and notebooks, pencils, pens, experience charts, etc.
- Manipulative Cyclical: table games, sports equipment, sand or water play, puppet play, test tubes, math shapes, scissors, carpentry tools, maintenance tools (brushes, brooms, carpet sweeper, cloths).
- Manipulative Non-Cyclical: materials consumed in activities such as woodworking, sculpting, painting, cutting, pasting and in making collages, clothes and puppets.
- Non-Powered: whistle, hand bell, and all musical instruments; magnifying glass, telescope, microscope; scales, paper cutter, abacus; bicycles, tricycles; typewriter or any other machine which is not powered.
- Powered: electric drill, electric bell, electric typewriter, intercom, telephone, sewing machine, all AV equipment.

Theoretically, all six different varieties of tools could be used in a space at any one time.

The observers found that three or more categories of tools were being used 48.3 percent of the time in SEF schools, 20.8 percent of the time in NSO schools, and 23.4 percent of the time in NST schools.

The amount of noise in a space was also taken as a measure of the activity. Three levels of noise were used. The first, called silence, referred to situations in which no one or only one person was talking; the second was the hum level in which there was a gentle hum of talking and activity; the third or high level was that which was judged likely to disrupt other people in the room or in adjacent areas. For example, singing and piano playing would normally indicate a high level, but the gentle strumming of a guitar would be in the second level.

Overall, the NST schools were the quietest while the SEF schools had the highest percentage of ratings in the middle noise level. However, in both SEF and NSO schools, about 16 percent of the spaces fell into the high noise category, whereas only 9.6 percent of the spaces in the NST schools were judged to have a high noise level.

In addition to rating the overall noise level for each space, it was necessary to get some idea of the number of distinct noises. The observers were asked to close their eyes and listen. They then simply counted the number of sounds that they were able to discriminate. Using this measure, the observers identified three or more sounds half of the time in SEF schools, one-third of the time in the NSO schools, and one-fifth of the time in the NST schools.

The scores obtained regarding movement of children, variety of student's tools in use, and the number of distinct noises were combined to form a scale of physical activity. The highest score on the physical activity scale described a space in which more than five children were walking around, many categories of tools were in use, and which had many distinct noises. A low score described a space in which all the students were seated at their desks working silently or listening to a teacher's instruction.

Table 3: Scale of Physical Activity by Type of School

	Physical Activity			
Type of School	Low %	Medium %	High %	N
SEF	16.9	66.1	17.0	1042
NSO	26.6	67.5	5.8	838
NST	43.1	50.4	6.5	944

SEF schools had more than double the proportion of high physical activity scores relative to the NSO and NST schools, 17.0 percent vs. 5.8 percent and 7.5 percent respectively. However, in the middle range of the scale, the SEF and NSO were similar (66.1 percent and 67.5 percent respectively). The NST schools scored lowest on the physical activity scale (16.9 percent). Medium size schools, and schools in middle level socio-economic areas had a greater proportion of low physical activity.

Distribution of People in the Space

Another question of concern was the number of groups that were using a space. Was the class sitting together as one group or dispersed in smaller groups? When a class was kept together, all the students generally were doing the same kind of task. In smaller groups, students could still all be doing the same task but there was more opportunity for different groups to be doing different things. A variety of groups in the teaching areas presumably permitted more children to learn in different ways and at different speeds.

Looking across types of schools, it was found that all children in a space were in one cluster 40.0 percent of the time in the NST schools, 31.0 percent of the time in the NSO schools and 25.5 percent of the time in the SEF schools. On the other hand, there were four or more clusters of student 44.3 percent of the time in SEF schools, 41.9 percent of the time in NSO schools, and 34.0 percent in the NST schools.

As one would expect the greater the number of clusters formed in one space, the smaller would be the size of the largest cluster. The average size of the largest cluster was smaller in the SEF and NSO schools than it was in the NST schools.

Where several clusters existed, one would expect more students to be working on their own. The results indicated that in SEF schools, three or more students were found working alone almost half the time (48.7 percent) while in the NSO and NST schools three or more students were working alone about 25 percent of the time, 26.5 percent and 28.2 percent respectively.

In the very real sense, the number of groups, the size of the largest group, and the number of people working alone is determined by the number of students in a space. Looking across types of schools, the observers reported that in the NST schools, there were 21 or more students in a space 77.7 percent of the time, as compared with 58.3 percent for the SEF schools and 56.4 percent for the NSO schools. At the same time, there were between one and twelve students in a space 8.0 percent in the NST schools as contrasted with 18.3 percent in the SEF schools and 22.1 percent in the NSO schools. To some extent, these findings probably reflected the lower occupancy rates in the newer schools.

The data generally indicated some common sense notions such as if the number of students in a space went up, the more likely that the number of clusters would also go up. However, the interrelationship among these variables also pointed to facts which were not as easily predicted. For example, there was a higher percentage of three or more students working alone in spaces containing 13-20 people than there was in spaces which contain 21 or more people. Put in a somewhat different manner, there was a higher percentage of no children working alone in a space that had 21 or more children than there was in a space which had one to twelve children. However, the data did illustrate that as the number of clusters in a space increased, the number of children working alone increased. These interrelationships will be further investigated.

Examination of the data showed that schools in medium socio-economic districts had the highest frequency of having 21 or more students in a space, were least likely to have students working alone, and were more likely to have only one cluster in a space. Schools in low and high socio-economic areas were similar in the number of students working alone, but those in high socio-economic districts had fewer children per space while those in low socio-economic areas had more clusters formed in their spaces.

Scale of General Activity

This scale was an overall measure of the general activity taking place in the schools. The scale was constructed by summing the scores from the scale of structure, scale of teaching style, and scale of physical activity. For simplicity of presentation, the index was reduced to a trichotomy of low, medium, and high general activity. All the variables in the scale were positively related. That is, if the furniture in the space were arranged with high definition and if there were only one focal point, then there was a good possibility that the teacher was acting formally and that the students were probably in one cluster and using few categories of tools. Such a space would have received a low general activity score and provided a pretty good picture of a "standard" school setting. On the other hand, if the furniture in the space were randomly arranged and if there were several focal points, it was likely that the teacher would be acting in an informal manner within easy reach of the children. There was also a good possibility that a variety of tools would be in use by several clusters of students and that several students would be working alone. Such a situation would yield a high general activity score and would, in many educators' opinions, typify desirable "open plan" education.

Table 4: Scale of General Activity by Type of School

Type of School	Scale of General Activity Low %	Medium %	High %	N
SEF	32.5	48.7	18.8	887
NSO	49.1	45.1	5.8	634
NST	58.6	31.7	9.8	941

A higher proportion of spaces in SEF schools ranked in the medium and high range of the general activity scale than did NSO and NST schools. The NSO schools had almost the same number of spaces in the medium range of the general activity scale as did SEF schools (SEF 48.7 percent, NSO 45.1 percent, and NST 31.7 percent). More spaces in the NST schools fell into the high end of the general activity scale than did NSO schools (SEF 18.8 percent, NSO 5.8 percent, and NST 9.8 percent).

Large schools in low socio-economic districts had the highest proportion of spaces in the middle and high range of the general activity scale. Small schools in the middle socio-economic areas had the highest number of spaces at the lower end of the general activity scale.

The number of students in a space was related to the general activity scale scores. Spaces with 13-20 students had double the number of high scores on the general activity scale as spaces with one to twelve students or those with 21 or more students (20.7 percent, 11.3 percent and 9.9 percent respectively). Half the spaces with between one to twelve students scored in the middle range of the general activity scale as compared with 40 percent in the spaces with 13-20, or 21 and more students. Finally, 50 percent of the spaces with 21 or more students scored in the low end of the scale, as contrasted to 40 percent of the spaces with one to twelve or 13-20 students.

As one would expect, spaces that only had one cluster had the highest proportion of sccres at the low end of the general activity scale.

There was also a positive realtionship between the number of individuals working alone in a space and the amount of activity indexed on the general activity scale. In other words, the more children working alone in a space the greater the total amount of activity in a space.

Summary

One point should be clarified. While it is true that overall the SEF schools had higher general activity patterns than did the NSO and NST schools, there were NSO and NST schools which had patterns as "open" as the SEF schools. At the same time, there were SEF schools which were not as "open" as some of the NSO and NST schools. The differences in level of activity could have resulted from differences between the teachers rather than from differences among the facilities. However, there were no significant differences across types of schools in the teachers' age, sex, years of formal education, years of experience, etc. The only significant difference that was found was that over half of the teachers in the SEF schools asked to teach in their schools compared with less than a quarter in the NSO and NST schools. Given that all the SEF schools were new and received a lot of publicity about their "flexibility", it is likely that a high proportion of open style teachers self-selected themselves into SEF schools. There is also the possibility of a "Hawthorne" effect as SEF schools hosted many visitors.

While it has been shown that there were different activity patterns in the three types of schools, it is not yet established whether or not these patterns have differential effects on what the children learn.

The results obtained and the above discussion led to the following general and specific conclusions:

1. The instrument generated data which can permit comparisons in activity levels not only between whole buildings but also between floors or sections within a building and between time periods. It seems ideally suited to monitoring the development of open space programs across a period of several years.
2. The SEF schools were quite distinct from NSO and NST schools. On the whole, in SEF schools there was less structuring of spaces, teachers were more personal and informal with the students, students worked more often in small groups or alone, and used a greater variety of tools than in NSO or NST schools.
3. Large schools which were in low socio-economic districts tended to have more "open" patterns than schools which were in middle or high socio-economic districts and which were either medium or small in size. Small schools which were in the middle socio-economic category tended to have the most traditional patterns. These results could have been due to the fact that the low socio-economic status schools which were large in size in this sample were also likely to be "inner city" schools. In recent years, these inner city schools have received more "special" teachers and larger amounts of money for tools than the other types of schools. These factors might have had something to do with the "open" patterns seen in these schools.
4. Teaching areas in which there were 13-20 students tended to have more "open" patterns than spaces with either a small or a larger number of students.
5. While it has been demonstrated that there are different general activity patterns in each type of school, the next step is to determine whether or not these patterns have differential effects on what the children learn. Next year the observation instruments will be refined and coupled with tests for such things as creativity, group problem solving and sharing of information.

Notes

(1) Metropolitan Toronto School Board. Study of Educational Facilities. "Annotated Bibliography of Research on Open Space Schools," Toronto, 1971.

(2) Mirrors for Behavior II: An Anthology of Observation Instruments. Edited by: Anita Simon and E. Gil Boyers. Philadelphia, Classroom Interaction Newsletter in cooperation with Research for Better Schools, 1970. 2 volumes.

(3) Proshansky, Harold M., Ittelson, William H., Rivlin, Leanne G., eds., Environmental Psychology: Man and his Physical Setting. New York, Holt Rinehart and Winston, 1970, p. 27-37, 173-183, 419-439, 658-668.

(4) Metropolitan Toronto School Board. Study of Educational Facilities. E5: Academic Evaluation-an Interim Report. Toronto, 1971. 210 pp.

(5) All tables significant at the .000 level.

COPING AND ADAPTING TO THE HIGH SCHOOL ENVIRONMENT(1)

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The research that is described in this paper is based upon the writer's thesis that knowledge of how persons cope with their immediate social environment requires simultaneous knowledge of the behavior of persons and social settings. The thesis also affirms that how persons and social settings function and affect each other should derive from a point of view that persons and settings are interrelated. Concepts and methods employed to assess the person should also relate to the life of social settings. Concepts employed to understand a specific social environment should specify how these concepts affect individuals. For the present writer, analogies from biological ecology provide the context for responding to these questions(2,3,4,5,6,7) An important ecological axiom is that varied environments produce different personal adaptations. This axiom has received substantial verification from ecological studies in biology.

A small but increasing amount of research in the behavioral sciences as well as personal experience suggest that we do in fact vary our behavior from place to place.(8,9) If we spend enough time in one place, we acquire, without always our awareness, specific and unique ways of carrying out our life's work that are consistent with the varied settings in which we live. The ecological perspective can help to generate knowledge that focuses directly upon commonplace events specific to the local setting and provides a rationale for improvising our methods to affirm how social environments affect their inhabitants.

The theoretical perspective derived from biological ecology emphasizes that persons and social settings have some very specific relationships and that any change in the behavior of persons affects the larger environment as changes in the operation of the social environment affect the life of individuals. For the research investigator it means that he is simultaneously examining reciprocal effects of persons and social settings and is trying to locate those events that are typical for the environment and those processes that affect social participation and the regulation of the society.

The style of ecological research is, however, somewhat different. It requires involvement with a social environment over a sufficiently long period of time in order to know which aspects of the social setting are salient. The research process is active without arousing persons who are members of the environment and distinct without attracting the preoccupations and attentions of multiple segments of the environment. This style of research can enhance our knowledge of socialization processes that affect the ways in which daily life is portrayed. Knowledge is made more authentic because the varied methods can focus upon the range of social settings. Research that begins with the premise that persons are related to the environment and research that employs methods that illuminate the culture of the social setting allows the varieties of the social units and their impact on their members to be presented as they naturally unfold. Knowledge gained in this way can illuminate what new organizations and resources are needed for improving the quality of the environment.

Two High School Environments: A Case Example

The present paper comments on the initial stages of a longitudinal study of a group of high school boys attending two demographically similar yet socially distinct high school environments. In the fall of 1968 when the boys were in the eighth grade, a stratified sample of 60 boys at each of the two schools was selected on the basis of their preferences for exploring or engaging their school environment. The construct of exploration refers to a preference for initiating and becoming actively involved in the culture of the school and includes items such as "I enjoy getting different groups to work together" and "I often have new ideas for class projects." Selection was based on a multiple method battery of questionnaires, thematic, biographical data and peer ratings.(10,11,12) Revisions were made in the selection battery in 1969 when the students were in the ninth grade (1969-1970 school year). During the 1970-1971 school year, when the students were beginning the tenth grade and their first year of high school, a biannual census(13), intensive structured interviews(14), and a study of informal group behavior(15) were employed to concentrate upon assessing how these boys developed personal competences and social skills as they began high school. The study includes, then, students with varied levels of exploratory preferences who are attending two similar yet distinct school environments. The purpose of the research program is to assess the effects of the school upon exploratory behavior. It is the premise of this work that the social life of a particular social environment does have specific and differential effects upon students as they move through their school. It is also expected that boys with varied levels of exploration preferences will adapt differently at the two schools because of each school's unique social culture.

The similarities and differences between the

TABLE 1

Differences between the Two High School Environments

(as presented in P. Newman)(17)

	School 1	School 2
1. Demographic Characteristics		
Sociocultural:	Suburban-industrial Middle class	Suburban-residential Upper-middle class
Student Enrollment and Exchange Rates*	1,963 18.7%	2,126 8.0%
Residence of High School Faculty	Faculty live in school district	Faculty live outside of school district
2. Architectural Design:	Multiple story Heterogeneous design	Single story Homogeneous design
3. Organization of Curriculum:	Ability grouping 10th graders take English with upperclassmen	No ability grouping 10th graders take English with 10th graders
	Comprehensive curriculum	College preparatory curriculum
4. Extracurricular Activities	Socially oriented	Task oriented
5. Formal Social Organization		
Principal	Autonomous Leader Long tenure in position	School board directed Facilitator Short tenure in position
Assistant principals	Clear division of labor	Similar responsibilities
Counselors	Division of students by grade & ability	Division of students by sex
Faculty	Departmental organization Faculty Council	Interdepartmental organization Implementation Comm.

*These are the average rates of population exchange (number of students entering and leaving the school/total school population) for three years (1968-1971).

two schools, especially their gross social structure, are outlined in Table 1.

Some of the recent findings about the processes of coping and adapting to the two schools will be summarized. Gilmore, employing a case study, interviewed a sample of 36 tenth grade boys (18 boys at each school with six boys at each level of exploration preference) (14). He was particularly interested in differentiating competences between students with preferences for different levels of exploratory behavior. He found that while the boys at School 2 reported a greater number of competences than the tenth grade boys at School 1 those with high preferences for exploration behavior at both schools reported that they express their competences within the settings of the school. Both of these findings were clearly significant with F ratios at the .01 level for a two-way analysis of variance. The boys with high exploration preferences also had significantly higher perceptions of their ability to influence their friends and their school environment and reported that they expected that parents and teachers would agree with their own ideals. Gilmore's work suggests that the boys originally selected in the eighth grade to have high preferences for exploration have continued to view the high school, at the beginning of the tenth grade, as an environment where they can express their competences. Gilmore's work also suggests that these boys do vary in their expectations and confidence to influence their environment.

This relationship between exploration preferences and participation in school affairs found by Gilmore via structured interviews is strengthened by the independent results reported by Edwards (13). Edwards administered a comprehensive assessment battery to the 195 boys in the total longitudinal sample. He found that boys with high exploration preferences express more identification with school, express more initiative, have higher self esteem and satisfaction with self, and say they know the principal of the school better than moderate or low explorer boys. Consistent with this pattern, boys with high exploration preferences also report that they have less social problems, are less unhappy at school, chat with a fewer number of students at informal settings in the school, and feel less watched and less uncomfortable in group situations. These findings represent significant F ratios beyond the .05 level and express a striking array of predicted relationships for the convergent validity of exploratory behavior. But we have a long way to go to account for much variance between exploratory preferences and the dependent variables. The Omega statistic (W^2) (16) employed by Edwards keeps our vanity low for the above relationships account for between only four percent and 15 percent of the variance between exploratory preferences and the other self-report personality measures. The follow-up phase of the longitudinal study will focus upon whether this initial involvement, reported by boys with high exploration preference, continues and is maintained in the same way at the two schools. The study also will be particularly interested in whether different levels of preference for exploration have varied adaptations at the two schools and whether the two schools have different social structures for attracting and repelling the boys who wish to be involved in the life of the school.

A few comments also can be made about the types of competences reported by the students in Gilmore's work. Between 61 percent and 71 percent of the first two competences mentioned in response to the question "What are some of the things you are good at and like to do?" related to recreational activities and sports. The relationship of exploration preferences and recreational competences at School 1 was positive and linear (45 percent, lo; 75 percent, mod; 92 percent, hi), while the relationship was more curvilinear at School 2 (83 percent, lo; 33 percent, mod; 67 percent, hi). These findings suggest that competences in sports at School 1 define the conditions for being involved in the culture of school. The boys at School 2 are reported to be involved in acquiring alternative competences via academic work, jobs or hobbies. We were also interested to find out that of the first two competences mentioned at either school only six percent at School 1 and three percent of the competences of School 2 were categorized as social competences. As the study continues, we will be particularly interested to see if the apparent and more active social environment of School 1 continues to nurture the development of more social competences than does the environment of School 2. At the beginning of the tenth grade the boys at School 1 expressed a slight tendency to be more responsive to their cultures than the boys at School 2.

What about the social structure of the high school environment and its opportunities for socialization? What settings for socialization are these schools providing? In a carefully designed representative sampling of the faculty and students at both schools, P. Newman (17) has found consistent differences in the quantity and quality of social interaction mentioned earlier. Not only was the quantity of social interaction reported by faculty and students to be greater at School 1 than at School 2 but the interaction between students and faculty took place both in more informal and formal settings at School 1 than at School 2. For example, differences in the quality of the interaction were found to exist in the following way. Students at School 1 reported that they perceived more personal interest expressed by the faculty and that they felt more comfortable in informal interactions with the faculty and administrators than students at School 2. The students at School 1 also reported that the faculty encouraged more active student involvement. Social norms were perceived as being clearer and consequences for norm violation harsher at School 1 than at School 2. As expected from the above findings, students at School 1 demonstrated a greater preference for the company of faculty and reported that social norms encouraged more involvement with their school. Students at School 2 reported a greater preference for the company of their peers than students at School 1. These findings of P. Newman give empirical support for the impression that the social environment at School 1 is more responsive to students who do wish to be members of that society. School 2 makes it more difficult for students to be active social participants.

These findings are also consistent with the work of Edwards (13) and his data from the stratified sample in the longitudinal study. Edwards found in his sample of high, moderate and low explorer boys that all students at School 1 expressed more positiveness about the principal, believed that the students had greater influence over fellow students and student government, and believed their school to be a better place than did students at School 2. There is a consistent portrait emerging that the boys with different levels of exploration preference will be participating in quite different cultures.

Barbara Newman's work has provided further evidence of the differences in the cultures of the two high schools (15). She created an informal group in which nine boys from Gilmore's study -- three high, moderate and low explorers -- at each school met for eight discussion sessions. Her interest was to assess the verbal and nonverbal behavior of boys within the group. Consistent with the findings of Edwards (13), P. Newman (17), and Gilmore (14), she found that there was more diversity in the responses of the boys at School 1. The boys at School 1 also were more expressive in their participation than the boys at School 2. They related more to her and expressed more affect to her and the other group members than the boys at School 2. A statistically significant finding that differentiated the behavior of the boys between the two schools was that the boys at School 1 asked the leader for information and sought her opinions more than did the boys in School 2 who were more cautious in their approach to the group and the group leader. We are interpreting these findings generated from this unstructured group setting in conjunction with the findings from P. Newman and Edwards as indicating that the culture of the schools is different and that School 1 serves as a more active and valued environment than School 2.

Further information was also obtained regarding differences in the expression of exploratory behavior from B. Newman's work. As mentioned above, the boys with high preference for exploration at School 1 were more expressive and involved in the group setting. But, the same was true for the low explorer boys at School 2. The high explorer boys at School 2 were less attracted to the group and less involved in group discussions. The findings of relatively less expressive behavior on the part of the boys at School 2 suggest that the less active milieu of School 2 may be "cooling" out the expression of affect. This work also suggests to us that the assessment of emotional feelings at School 2 will be more difficult in the future. If the boys with high exploration preferences at School 1 continue to be expressive, it will be a relatively easier task to learn about their adaptation than the more reserved response to novelty characteristic of the boys at School 2.

One of the most striking findings in the work of B. Newman was the vast individual differences she observed in the behavior of the boys independent of their level of exploration. The boys at both schools showed differences in physical size, in their interests and verbal skills. From the accounts of the wide range of responses to the group, we are beginning to subdivide the exploration groups to include categories of varied developmental levels. Exploration at a lower developmental level, for example, may be expressed via large body movements. At more advanced developmental levels, exploration preferences can be channeled into more ideational and perceptual activities. If such distinctions can be assessed, the research program provides an opportunity to learn more about the interaction of social forces and developmental levels which affect coping preferences in the period of middle adolescence.

The work of Philip Newman concentrated on assessing the social structure of the schools by using a representative sampling of the faculty's and students' reports of the quality and quantity of social interaction at each school. B. Newman used social interactions during informal group discussions to further characterize the culture of the schools. Todd (18) used still another approach to define the culture of the schools, namely, a case study of the helping behavior of two subcultural groups within School 2. His method involved a series of successive procedures including informal interviews, sample surveys, and an intensive study of the boys through daily log reports of helping acts. This intensive study of the help-giving process in two subcultures provided validation of the nebulous quality of the social structure existing in School 2 when he found that students in both subcultures knew very little about the details of the rest of the social environment that did not involve them directly. A few comments will be made about the unique approach and the findings of this study.

The two subcultural groups that were selected represented quite distinctive qualities. One group was more visible within the formal social structure of the school, while the other group showed minimal involvement in school affairs yet participated very actively in a competing culture outside of school. In response to inquiries in the sample survey, Todd found that the non-school affiliative group, whom he called the "tribe," reported more reciprocal help-giving acts than the group he referred to as "citizens." When both groups of boys kept log reports of their helping behavior, however, the citizens showed a tendency to engage in more reciprocal helping transactions and were involved in receiving and giving help with girls more often than the tribe members. The differences in response to the two research methods is encouraging rather than disconfirming. A subgroup such as the "tribe," that is marginal to the main culture, could be expected to present an image of solidarity to an outside research investigator. The opposite response could be expected to be true for a member of the citizen culture who responds to "tests" more casually and who positively values preparing autobiographical reports for a "diary" of help-giving behavior. The increased appearance of help-giving incidents with girls in the lives of the citizens, as reflected in their log reports, is interpreted as representing the authentic and genuine significance of girl friends to the citizens in their personal interactions. The tribe members, on the other hand, who live in a more "routine," male-dominated culture, view social interactions with girls as infrequent and conflicting events. It appears, according to the results that Todd has reported, that the "tribe" pays a price in being a closely knit, cohesive male subgroup; namely, their marginal status in the high school environment prevents their seeing a woman in any other way than as a sexual object.

The dynamic interdependence between citizens and tribes was highlighted by the different responses to the two research methods. Todd's work has provided the research program with a provocative approach of funneling down to the social structure and revealing the clarity of the social environment without losing the complexities of life patterns of the two subcultures. The choice of helping behavior, derived from the ecological perspective of the interrelationships of persons and natural settings, provides compelling findings for the subcultural groupings at School 2. We have learned that the socialization of help-giving competences does very from subcultural group to subcultural group. We are now ready to examine in more detail the antecedents for these relationships and to document the varieties of ways in which persons and settings affect one another.

The studies of persons, such as the work of Gilmore, Edwards and B. Newman, and the studies of the social structure of the schools, such as the work of P. Newman and Todd, are examples of developing complementary methods and interrelated studies to understand the ecology of varied environments. On the basis of current work, it has been established that the social environments of the two high schools are perceived as different social climates and that boys with different levels of exploration preferences express different personal characteristics. As the work proceeds, the differential impact of the schools upon the socialization of exploration preferences can be assessed.

Implications for the Study of the Ecology of Socialization

On the basis of the present studies, it seems reasonable to discuss the social environment of the first school as a location where there is a variety of informal settings within the school for students to actively express their ideas and to participate in school affairs. Students who vary in their mode of accommodating to the school can do so, it seems, if they have the principal's expressed approval and if extracurricular activities absorb students with contrasting styles of living. There is a definite social organization working at School 1 which creates a forum for involving new resources. The social functions of the environment are intact; social settings for informal and formal interactions are available; and clear social norms are present to socialize new members. What is not so clear is how tolerant the setting is or how rapid organizational problems can be dealt with or how many extracurricular opportunities can be created that diverge from the values of the school principal.

At School 2 it is expected that there are diverse viewpoints within the larger community surrounding the school, but this latent variety is relatively unknown to the school faculty. The social norms generated by the school faculty seem to serve to reduce outside influences affecting the life of the school. At the present time the specific sources for such norms are unclear. One guess is that such school policies reflect the concerns of the local school board and community leaders to keep the school free from more intrusive or conservative political influences that may place new demands upon the faculty and administration which they prefer not to meet. One of the consequences of this tension in keeping out external forces is that the faculty and students do not seek out and value the competences present in the school and larger community, and they go unnoticed. From this perspective it appears that School 2 is neither efficiently utilizing the resources that are available to them nor actively working to create values for the planned development of students or the social organization of the school. Instead, social norms operate to reduce external influences affecting the school and, perhaps most unfortunately, to reduce whatever opportunities there are for student/faculty interactions as well as to cement the differences between student and faculty cultures.

Implications for the Study of the Ecology of Competence

Our findings at this point in time suggest that one environment seems to behave as if it were a "scout camp" while the other generates a great deal of ambiguity. The research program is concerned with the consequences for students attending these two different schools. At School 1 the question is what happens to students who are not congruent with the modal social norms of the environment, who care about their school but choose not to become members of the "scout camp." At the second school the concern is for students who care about their school but who cannot locate the social supports for their activities. Our guess is that these two requirements for adaptation will have divergent effects upon students' future participation in school and their immediate and long-term preference for adults' help-giving roles. The thesis of the study is affirming that the quality and diversity of the social environment has definite effects on the ways in which young people learn to cope with environmental demands. If such effects are demonstrated, the study can provide concepts and empirical data for defining types of social interventions that can be applied to social environments.

The present work has developed from implicit criteria for a model "ecological" environment. The six criteria are presented in order to make explicit the benchmarks by which each school environment will be assessed. The ecological thesis affirms that personal development can be accomplished if criteria for the socialization of competences like the following are met: 1) a diversity of formal and informal settings encourage social interaction; 2) a variety of informal roles in the social environment allows for spontaneous help-giving and for personal interactions across divergent roles; 3) varied competences are valued and persons contribute these competences to the larger community; 4) there are clearly recognized social norms for relating to the surrounding external environment; 5) there is a commitment to examine the impact of the social environment upon its members; 6) there is a value for designing a social environment where the dominant activities take into account the diverse cultures of members. The future work will describe these two schools and evaluate them in terms of these performance criteria.

These criteria will help the present work to analyze the mechanisms and those social forces that evolve in response to the demands of varying persons along with the means that different persons employ to cope with environmental demands which are incompatible with their aspirations and hopes.

Future Hypotheses

As the study continues, future work will focus upon differentiating characteristics of the social environment which are specifically salient for boys with different levels of exploration while simultaneously documenting the particular ways of life of the schools. From here on our task is to differentiate the socialization processes by hypothesizing how students who are members of different school environments learn contrasting competences. If we are successful, we then can concentrate upon creating plans for organizational and personal change which derive from these ecological findings.

Our thinking is starting to move in the following direction. Students at School 1 are expected to be able to learn how to interact with adults in authority roles, initiate social interactions with strangers, and feel optimistic about their own ability to influence the events of the school. Students at School 1 are expected to participate quite comfortably in hierarchical relationships, particularly with persons with assigned power. What the students are expected to learn as members of School 1 is to seek out, engage, and deal with those with influence. Students at School 2, on the other hand, are expected to be socialized to move on to their achievements without deviating from an abstract and minimally-shared objective and without participating actively in their immediate social settings. What the students at School 2 have, they are expected to keep and parlay for still greater achievements.

The students at School 1 are predicted to be involved and committed to making their world effective, while the students at School 2 are concerned with insuring that they maintain their valued position. In wondering about the potential strains for the different patterns of socialization, the students at School 1 are expected to be naive about the realities of social milieus except for social settings which are very similar to their own. Their view of the world is expected to be cognitively more simple than the world view of the students at School 2. Students at School 2, in contrast, are expected to have a more realistic, if not cynical, view of how social institutions function and are expected to lack the emotional investment to actively participate to bring about change. On the basis of these ideas the boys with high preference for exploration at School 1 are expected to have a more personally satisfying and adaptive high school career than the boys with high preferences for exploration at School 2. The high explorer students at School 2 will feel more psychic strain as they attempt to engage and participate in a vague and unresponsive environment.

During the next two years of the research, increased attention will focus on the relationship between personal preferences, social structure and socialization. As we concentrate upon this task, our aim is to highlight the varieties of adaptive behavior of students who have the same predispositions to act. The hypotheses derive from our view of the boys and from the environments where they are students.

Conclusion

The ecological thesis is that different persons' competences vary in different environments. The comments in this paper have illustrated how a longitudinal study carried out in two high schools is an example of one approach to understanding how the natural features of social environments affect their members. At the conclusion of the research, it is hoped that knowledge will be available to illuminate socialization processes in high school environments. Equally important is the aim that the research will furnish cornerstones for the design of new social processes at the two schools. It is hoped that such new social settings can be authentic locales for youths to develop social competences in order to deal with future and unknown environments.

Notes

(1) This paper, prepared for the Third Environmental Design Research Association Conference, UCLA, Los Angeles, January 24-27, 1972, is derived from comments presented at a symposium entitled "Social Competence and Mental Health," 79th Annual Meeting of the American Psychological Association, September 6, 1971. The research described in this paper has been supported by research grant MH 15606 from the National Institute of Mental Health.

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PATTERNS OF PHYSICAL CHANGE IN SIX EXISTING HOSPITALS

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Problem

Change and growth have been the most important facts in the physical life of hospitals during the last 20 years. In 1950 the average hospital contained approximately 550 sq. ft. per bed. Today the figure is approximately 950 sq. ft. per bed excluding medical office buildings. In addition to this increase in space per bed, the number of beds in most hospitals has also grown.

At the same time changes in medical techniques and standards of care and accommodation have generated demands for many new kinds of space. This study attempts to define change in six existing hospitals from 1950-70. If patterns of change can be discovered, they will assist in shaping future design. This study constitutes phase I of a larger effort which will use the methodology developed and refined here on a larger sample (25 hospitals).

The six hospitals surveyed had the following characteristics:

Hospital #01

Location: Suburban
Ownership: District
Age: New Hospital opened in 1954
Size: 154 beds at opening
120 beds added in 1961; 374 beds total
44 beds added in 1971; 418 beds total

Change Summary:
Additions: 4
Major remodelings: 6
Minor remodelings: 17

Hospital #02

Location: Suburban
Ownership: Built proprietary; changed to private non-profit in 1963.
Age: New hospital opened in 1963
Size: 156 beds at opening
2 beds added in 1963; 158 beds total
16 beds added in 1968; 174 beds total
16 beds added in 1970; 190 beds total

Change Summary:
Additions: 5
Major remodelings: 0
Minor remodelings: 7

Hospital #03

Location: Suburban
Ownership: District
Age: New Hospital opened in 1950
Size: 106 beds at opening
134 beds added in 1955; 240 beds total
7 beds added in 1957; 247 beds total
101 beds added in 1961; 348 beds total

5 medical/surgical beds deleted and 85 extended care beds added (adjacent building purchased) in 1967, 428 beds total.

86 extended care beds added in 1968; 514 beds total.

Change Summary:
Additions: 4
Major remodelings: 11
Minor remodelings: 20

Hospital #04

Location: Suburban
Ownership: District
Age: New Hospital opened in 1961
Size: 277 beds at opening
30 beds added in 1962; 307 beds total
154 beds added in 1964; 461 beds total
6 beds added in 1971; 467 beds total

Change Summary:
Additions: 6
Major remodelings: 1
Minor remodelings: 23

Hospital #05

Location: Urban
Ownership: Private non-profit
Age: In operation since about 1900. Most of the hospital in post 1950 buildings.
Size: 281 beds in 1950
64 beds added in 1958; 345 beds total
126 beds added in 1965; 471 beds total

Change Summary:
Additions: 4
Major remodelings: 14
Minor remodelings: 19

Hospital #06

Location: Urban
Ownership: Private non-profit
Age: In operation since about 1900
Size: 350 beds in 1950
16 beds deleted in 1969; 334 beds total

New building replaced all old beds.

Change Summary:

Additions:	3
Major remodelings:	6
Minor remodelings:	18

Methods

Each hospital was analyzed by describing physical changes which had occurred during the study period in the following departments: Radiology, Laboratory, Surgery, Emergency, Transportation and Nursing Units. The accompanying form was used for this purpose.

Limitations to this technique are:

1. Many changes are accomplished by maintenance crews and not recorded well.
2. Reporting of change is dependent on the subjective recall of staff members. In some instances, changes antidate present staff memories.

Scope of change was described by determining the percentage of the individual department affected and the cost per sq. ft. of the change. Maintenance was differentiated from change by being described as replacement of worn out items without functional alteration. Significant upgrading or modernization, such as replacing hard surface floors with carpet, was described as change not maintenance, but this type of change occurred seldom.

Further refinements to the study will include an evaluation of the amount of overbuilding relative to work load which occurred at the start of the study and in each of the changes since. Obviously this radically affects the amount of subsequent change. In the case of district hospitals in particular, the necessity for bond issue financing tends to create overbuilding to avoid going to the voters on a frequent basis. Future work will also refine evaluation of the relationship of layouts after change to current standards for such departments in new construction.

A most important aspect of the study in terms of gathering useful information for future study was the consideration of each change in terms of how it was affected by the options available; i.e. did change take place in a particular way or not take place at all because the basic plan made such change extremely difficult. Obviously such evaluations are considerably subjective but they do strike at the core of the problem since it became clear that existing patterns of design often closed out many opportunities for easy addition.

Nursing Unit Change Patterns

Nursing Units accounted for almost half the total number of changes. Most of the changes (about 75%) were remodelings. About a third of these were minor changes to just one room to accommodate new uses or to improve the efficiency of use.

Most other changes, both major remodelings and building additions, were to improve operating efficiency and accommodate new or expanding programs. In only a few cases was physical deterioration a major cause of change.

Increases in the number of beds were accomplished primarily by building additions, not by nursing units expanding into other areas. Growth of specialty nursing units, however, was frequently by means of remodeling existing nursing areas.

Changes to nursing units occurred quite independently from changes to other departments. Most were accomplished by internal remodeling or major building additions; there were almost no extensions into other departments' areas. Also, nursing areas were never remodeled to other major medical uses; only changes to lower-intensity medical use, such as clinics, or to non-medical administrative uses were made.

Planning Implications

The great deal of minor remodeling in Nursing Units reflect two factors, 1) the "swiss watch" character of their operation in which small changes to these tightly designed units can effect what are perceived as important improvements in operation, and 2) the fact that most minor remodeling can go forward early without seriously effecting function. Minor remodeling had little impact on shape or vice versa.

More serious remodeling in the Nursing Unit had two causes - occasionally to upgrade accommodations, and more often to alter function from general nursing to specialty nursing such as coronary care. In these specialty unit remodelings and the one case of a small addition to an existing unit, shape did affect the character of the remodeling most seriously. It was also important with respect to desired changes which did not take place, particularly the enlarging of bed counts in units.

Nursing Units operate, change internally, and expand independently from other departments, and their rate of change is the highest of the departments studied. The nursing part of a hospital should be designed to accommodate independent change, even to the point of replacing nursing buildings without affecting the rest of the hospital.

They can be considered as separate buildings, connected to the rest of the hospital only by transportation and communication systems. They should be designed to accommodate only nursing and eventual non-medical administrative functions.

The character of remodeling undertaken indicated that long column spaces were not important -- nor were available mechanical spaces of the scope provided by interstial floors. Such floors do add some convenience for maintenance, but the cost/benefit is doubtful.

Major remodeling characteristics indicated that shape was important. Specialty care units seldom occupy the entirety of a normal nursing unit. Ideally, their units should be shaped so that they can be subdivided without forcing traffic to pass through one subdivision to reach another.

Extensive remodeling in Nursing Units, such as adding new toilets and showers throughout, is very undesirable. Capital costs were high and loss of revenue during renovation was a serious problem. Yet it is clear that over the past 20 years design standards for Nursing Units have changed dramatically. If this pattern of change in standards and difficulty of remodeling continues, it is clear that Nursing Units should be designed with eventual demolition or conversion to other uses as part of the program.

Surgery Change Patterns

Changes in surgery departments accounted for about 19% of the total of all departments. Major causes were increased work load and new procedures, programs and equipment. Most changes were remodelings of existing areas. Area additions resulted in 22% of the changes, and most of these were building additions rather than extensions into existing areas.

The most significant change pattern identified was that expansions of recovery rooms, staff lounges and lockers, and other ancillary areas accounted for most of the area addition and remodeling changes. Operating room areas rarely expanded, but were modernized to accommodate new procedures and equipment principally by the addition of new lighting and casework. Frequent maintenance work on mechanical systems was noted.

Planning Implications

A general condition for Surgery is that the use of operating rooms (those not intentionally shut down) not be interfered with during changes. Since most change in the operating room area involves mechanical system and equipment, rather than architectural changes, arrangements that allow independent work on mechanical systems, such as interstitial floors, are called for.

Expansion of the department was primarily of ancillary areas; their extension should be allowed for. Also, the expansion of the operating room suite should be allowed for as a block of operating rooms. Implications are that "soft" areas around surgery should be provided into which easy expansion is possible (including shelled space in new construction), as well as an exterior location to allow adjacent building additions.

Radiology Change Patterns

Equipment changes occur about every five years and require extensive remodeling of individual procedure rooms. Expanding work load is the other major cause of change. More patients and the development of new techniques increase the number of procedures that must be performed resulting in demands for more space.

Planning Implications

Moderately frequent equipment changes make necessary the accessibility of electrical systems, and much less frequently, H.V.A.C. systems. Although interference with space use is not as critical as in surgery, the complexity of equipment and frequency of change may justify an interstitial space for this department.

Increasing the size and number of X-ray machines may necessitate larger main electrical feeders, transformers, and stand-by generators as well as internal circuit changes. Transformer and generator areas should be expandable.

Since departmental capacity is directly related to the number of X-ray machines available, and there is a proportional need for processing, storage, viewing, staff, and patient areas as the number of machines increases, the whole department area expansion can be proportionally larger than that required for similar capacity increases of other departments. Implications are that the department be located to allow for a great deal of expansion by having adjacent internal "soft" areas and a peripheral location which can be expanded externally.

Laboratory Change Patterns

New equipment and expanding work load are the major causes of change. There is not the direct relation between work load and area requirements that exists in other departments because compact automatic analysis machines are taking over work formerly done manually. The primary change pattern for laboratory is that area growth can be put off for long periods with work load increases being accommodated by extended working hours and fast automated machinery. Much other new equipment must also be accommodated, but most is portable in nature and necessitates few building changes. Electrical systems are worked on frequently; this often requires opening partitions for access when services are contained within them. H.V.A.C. systems are altered occasionally.

Planning Implications

Capability of expansion is not as strongly indicated as in surgery or radiology but access to mechanical equipment for changes and for the installation of new and sophisticated machines is important.

Emergency Change Patterns

Emergency departments changed the least of any studied. Two causes of change were characteristic. One was the expansion of emergency service work load; this was primarily in the suburban hospitals (most San Francisco emergencies are handled by the city). The other primary change was emergency departments assuming drop-in clinic functions, in effect replacing doctors' offices. Both of these factors caused departmental size increases through the additions of examination and treatment rooms, and emergency operating and X-ray rooms.

Another role change is that emergency departments are becoming the after-hours admitting office for the whole hospital. This had caused extensions of emergency department administrative areas to accommodate clerks and files from the admitting department.

Planning Implications

Emergency is likely to grow in size and change in function as the trend to more out-patient clinic services continues. Area extensions should be allowed for and a relatively close relation to admitting and other administration areas might be called for if emergency is to function as an after-hours hospital entrance.

DISTRIBUTION OF CHANGES

APPENDIX 1

NURSING

	No. of Changes	Percentage
Remodeling		
No area added to the department	60	69%
Area added to the department	7	8%
Sub-total remodelings	67	77%
Building Additions	20	23%
Total Changes	87	100%

$\frac{\text{87 changes in nursing}}{\text{191 total changes all depts.}}$ = 45% of all changes were in nursing

SURGERY

	No. of Changes	Percentage
Remodeling		
No area added to the department	21	58%
Area added to the department	7	20%
Sub-total remodelings	28	78%
Building Additions	8	22%
Total Changes	36	100%

$\frac{\text{36 changes in surgery}}{\text{191 total changes all depts.}}$ = 19% of all changes were in surgery

RADIOLOGY

	No. of Changes	Percentage
Remodeling		
No area added to the department	16	54%
Area added to the department	7	23%
Sub-total remodelings	23	77%
Building Additions	7	23%
Total Changes	30	100%

$\frac{\text{30 changes in radiology}}{\text{191 total changes all depts.}}$ = 16% of all changes were in radiology

LABORATORY

	No. of Changes	Percentage
Remodeling		
No area added to the department	9	48%
Area added to the department	5	26%
Sub-total remodelings	14	74%
Building Additions	5	26%
Total Changes	19	100%

$\frac{\text{19 changes in laboratory}}{\text{191 total changes all depts.}}$ = 10% of all changes were in lab.

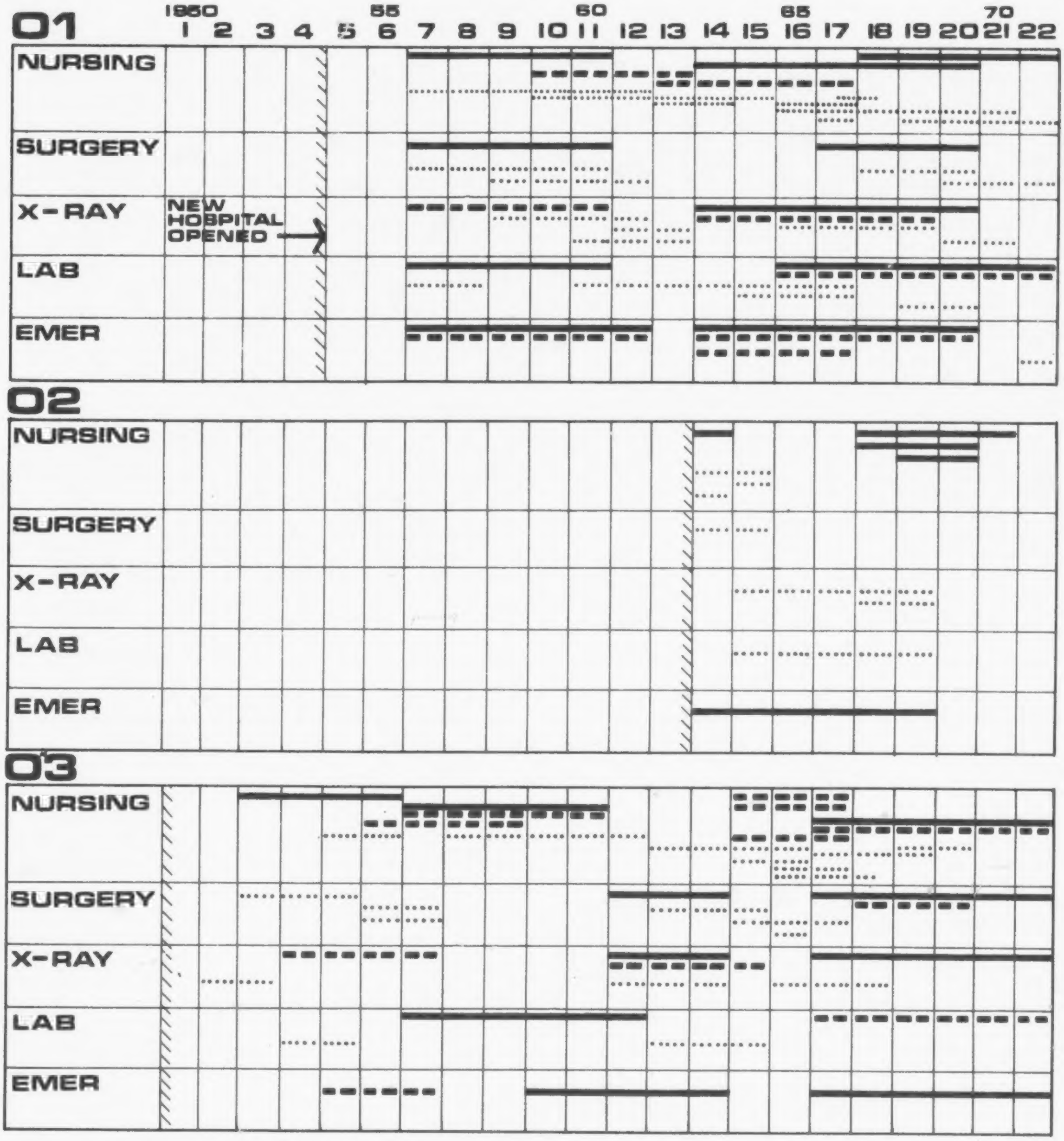
EMERGENCY

	No. of Changes	Percentage
Remodeling		
No area added to the department	8	42%
Area added to the department	5	26%
Sub-total remodelings	13	68%
Building Additions	6	32%
Total Changes	19	100%

$\frac{\text{19 changes in emergency}}{\text{191 total changes all depts.}}$ = 10% of all changes were in emergency

CHANGE HISTORIES

APPENDIX 2, PAGE 1

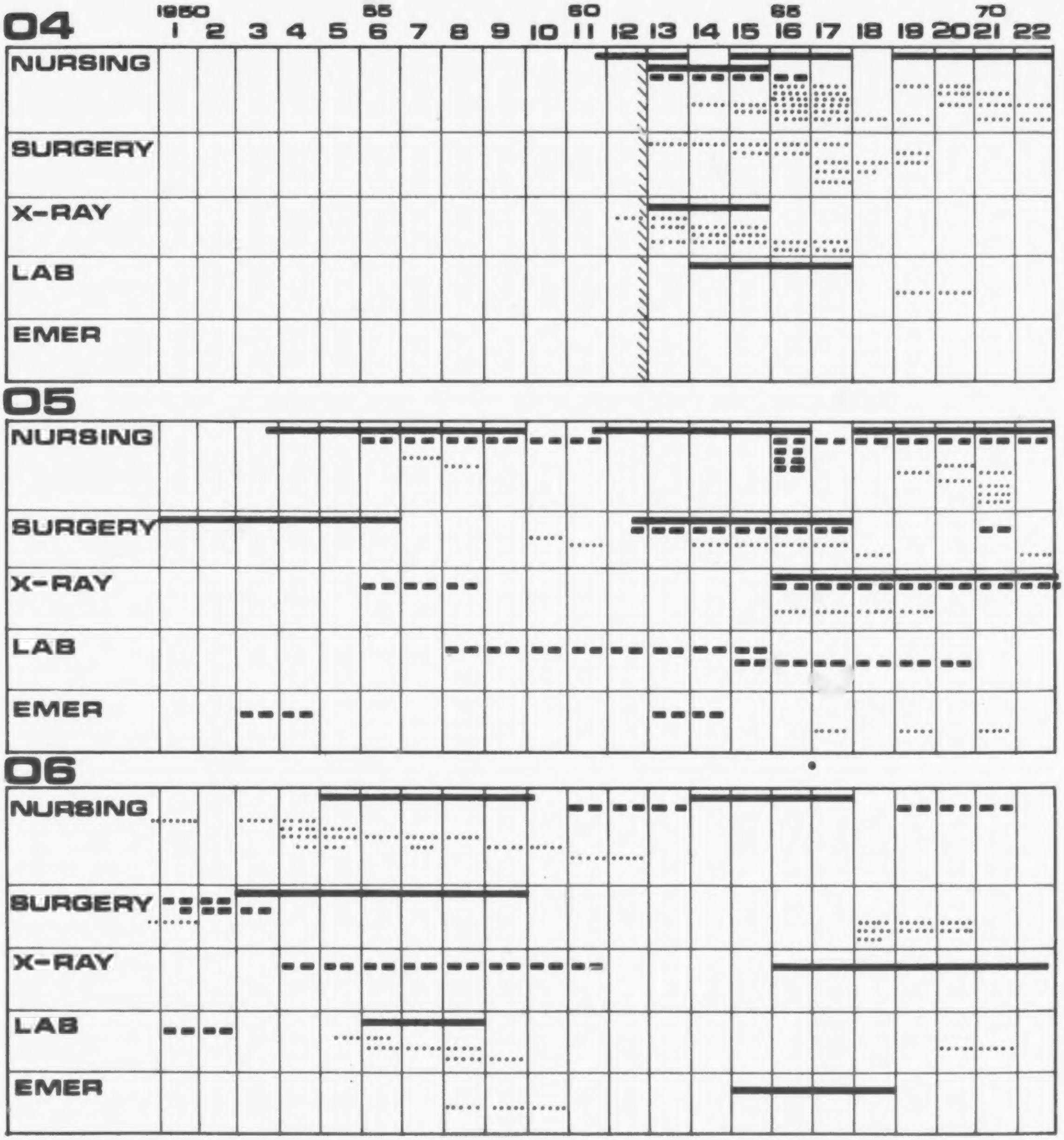


CHANGES FROM BEGINNING OF PLANNING TO COMPLETION OF WORK

BLDG. ADDITION ▬▬▬ MAJOR REMODEL ▬ ▬ ▬ ▬ MINOR REMODEL ··············

CHANGE HISTORIES

APPENDIX 2, PAGE 2



CHANGES FROM BEGINNING OF PLANNING TO COMPLETION OF WORK

BLDG. ADDITION ——— MAJOR REMODEL ▬ ▬ ▬ ▬ MINOR REMODEL ....

SAMPLE CHANGE RECORD FORM

APPENDIX 3

PATTERNS OF HOSPITAL CHANGE

HOSPITAL: 05 DEPT: RAD. TIME RANGE: 1955-57

1. TYPE OF CHANGE

INDEPENDENT ☑ DEPENDENT ON OTHER CHANGES ☐ PART OF COMPREHENSIVE PROJECT ☐

	SEVERITY			BLDG. ELEMENTS EFFECTED									
	MAJOR	INTERMED	MINOR	PARTITIONS	FLOORS	CEILING	PLUMB.	CASES	HVC	ELECT	LIGHTING	COMMUN	OTHER
EXTERIOR ADDITION													
INTERNAL EXTENSION		●		●	●	●	●		●	●	●		
REMODEL													
RELOCATE													

2. CAUSES & RELIEF

	CAUSES			RELIEF		
	OVER-RIDING	VERY IMPORT	INFLU-ENTIAL	MORE THAN SUFFICIENT	SUFFIC-IENT	LESS THAN SUFFICIENT
WORK LOAD		●			●	
NEW PROCEDURE						
EQUIPMENT	●				●	
BLDG. CODES						
PROFESSIONAL STANDARDS						
LAYOUT EFFICIENCY						
NEW PROGRAM						
PERSONAL PREFERENCE						
CHANGE ELSEWHERE						
INSUFFICIENT AREA	●				●	
OTHER						

3. SPEED OF RESPONSE

DATE PLANNING BEGUN: 1955

DATE OF OCCUPANCY: 1957

ELAPSED TIME: 2 YRS.

4. PROVISIONS FOR FUTURE CHANGE

- AVAILABLE UNUSED SPACE ☐
- EXTRA SPACE (LOW DENSITY USE) ☐
- EXTRA SERVICES ☐
- DEMOUNTABLE PARTITIONS ☐
- INTERSTITIAL SPACE ☐
- EXPANDABLE EXTERIOR LOCATION ☑

5. DISRUPTIONS

	SEVERE	INTERMED.	MODEST
NOISE			
DIRT			
OBSTRUCTIONS			
BLDG. SERVICES			
ACTIVITIES			
LOSS OF SPACE			

6. PREVIOUS CHANGES

TIME SINCE LAST CHANGE:

CHARACTER	MAJOR	INTERMED.	MINOR
EXTERIOR ADDITION			
INTERNAL EXTENSION			
REMODEL			
RELOCATE			

7. ALTERNATIVES

TYPE

	EQUAL	PREFERABLE
EXTERIOR ADDITION		●
INTERNAL EXTENSION		
REMODEL		
RELOCATE		

REASONS NOT CHOSEN:

- NOT THOUGHT OF ☐
- BLDG. CONSTRAINTS ☐
- LAND CONSTRAINTS ☐
- BUDGET CONSTRAINTS ☑
- OTHER ________ ☐

8. MISCELLANEOUS: REMODEL 2 STORAGE RMS. TO X-RAY RMS.

12-6-8

ATTITUDE CHANGES AFTER BRIEF ENCOUNTERS WITH MENTAL PATIENTS IN RESIDENTIAL AND INSTITUTIONAL ENVIRONMENTS

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The treatment and conception of psychiatric patients in the United States has changed radically in the last thirty years, particularly in the last decade (Cohen & Struening, 1962). As the influence of the psychoanalytic orientation began to decline after World War II, there emerged an increasing concern about the patient's social context. During the 1950's most of the innovations in theory and practice focused on psychiatric hospitalization and aspects of the hospital milieu (Rabin, 1970). Most recently there has been a movement in the mental health field--known variously as social psychiatry, community psychiatry, and community mental health--which attempts to offer treatment alternatives to hospitalization which are minimally disruptive to the patient's social and community life.

In connection with the increase in community mental health programs, there has also been an increased exposure of the patient to the general community in "non-hospital" settings. Concomitantly with the latter change in treatment locations, or environments, a great deal of interest has developed regarding attitudes about psychiatric patients and emotional disturbance held by the general public (Rabin, 1970). Much of the increased interest in the general public's attitudes toward emotional disturbance stems from the recognition that the success in establishing community based treatment facilities is in large part dependent upon the attitudes of the general community toward psychiatric patients and emotional disturbance, and a further recognition of the possibility of influencing those generally negative attitudes through a change in treatment setting.

The present study was designed to investigate the relationship between an individual's attitudes toward mental patients and mental illness as they are affected by experience with psychiatric patients in specific settings. More specifically, the intent was to analyze the changes in college students' attitudes toward mental illness which occur as a result of a brief encounter with chronic schizophrenic outpatients in two different behavior settings: 1) a Day Treatment Center for chronic schizophrenic outpatients on Veterans Administration Hospital grounds, and 2) a residential home setting within the community. The primary question was, "Does the behavior setting in which a subject encounters psychiatric patients exert an influence on the direction and intensity of his attitudes toward psychiatric patients and mental illness?"

Roger Barker (1965, 1968) as well as other ecologically oriented psychologists (Bijou, Peterson, & Ault, 1968; Gump, Schoggen & Redl, 1957, 1963; Raush, Farbman & Llewellyn, 1960) have argued that the immediate socio-physical environment (behavior setting) is an important determinant of behavior. It appears that most of the behaviors of the inhabitants are facilitative or at least compatible with the setting. Wicker (1970) has referred to this phenomenon as "behavior-environment congruence" (p. 258).

Based on the notion of behavior-environment congruence it would be expected that in treatment programs which differ in setting, the behavior of both the patients and subjects encountering the patients would differ. In the present study, the behavior of the subjects encountering the patients in the two different settings (hospital and community) was of primary interest. The specific behavior of interest was the subjects' expressions of their attitudes toward mental patients and mental illness in general.

Circumjacent to the mental hospital behavior setting are many environmental cues which are congruent with deviant behavior (e.g., fences, differences in architecture, zoning, aides, guards, etc.) which act as discriminative stimuli eliciting unfavorable consequences (negative attitudes) for the inhabitants of that setting. Whatever the nature of these deviancy signalling cues, it was reasoned that it would be less likely that they would be present in a residential home setting located within the community. Therefore, it was hypothesized that subjects encountering patients in the community setting would express post-encounter attitudes which are more favorable toward mental patients and mental illness than would comparable subjects encountering the same patients in the hospital setting or subjects participating in a control group who had no encounter with patients in any setting.

There is no previous experimental investigation concerning the effect of treatment setting on attitudes towards those regarded as deviant. However, Maslow and

Mintz (1956) offer some supportive evidence for the general notion that the perception of an individual is congruent with certain environmental cues offered by the setting. They found that subjects produced correspondingly different ratings of the "fatigue-energy" and "displeasure-wellbeing" of facial photographs, depending on the environment in which the ratings were made: a "beautiful," an "average," or an "ugly" room. Mintz (1956) further noted that the environmental effect continued over a three-week interval without "adaptation" to the environment. The Maslow and Mintz (1956) and the Mintz (1956) findings are seen as consistent with the present hypothesis that the environmental effect of the community setting is more congruent with a favorable perception of the patient than is the environmental effect of the hospital setting.

Methods and Procedures

Subjects

The subjects (Ss) for the study included 72 college freshmen and sophomores enrolled in Introductory Psychology courses at the University of Houston, who were randomly assigned to six groups of 12 Ss each. T-tests indicated that no significant differences existed between Ss across the six groups for either motivation to volunteer for an experiment or age. Calculation of percentages indicated that such demographic variables as major subject of study, level of education, occupation, and religion were randomly distributed across groups. There were 39 male and 33 female Ss who were approximately equally distributed across groups.

Target Population

Eighteen patients from the Houston Veterans Administration Day Treatment Center between the ages of 20 and 60 years, the majority of whom were diagnosed "chronic schizophrenic," volunteered to serve as the target population. Four staff members were also present in both settings.

Settings

Hospital setting (HS): The Day Treatment Center is located in one of the newer wards of the Houston Veterans Administration Hospital. Although the building which houses the Day Center is built in typical Veterans Administration ward fashion, the interior deviates from what one expects to find in the typical psychiatric ward. The furniture has been selected to give the appearance of a living room setting and to encourage various forms of social interaction. There are large comfortable sofas and chairs, a pool table, a ping-pong table, and card tables. These physical aspects plus the absence of beds, nurses, medical paraphernalia and M.D.'s make it somewhat different from the traditional inpatient psychiatric ward. However, it is located on the Veterans Administration Hospital grounds and is clearly a part of the hospital environment which is marked off from the surrounding community by a fence, deviations in architecture, and distinctively dressed hospital personnel and patients.

Community setting (CS): The community setting was a large private residence located in a residential area of Pasadena, Texas. The exterior and interior of the house were tastefully designed, but not unlike what one would expect to find in this upper middle class residential area of town.

Group Drawing Task

In order to insure the equivalency of activities in all behavior settings, each encounter was focused on a group drawing. In each of the experimental conditions (CS and HS), two newsprint drawing pads were set up and the inhabitants of the setting were evenly divided into two groups with equal numbers of patients. Everyone was encouraged to draw something on the newsprint that represented something about themselves which they wished to express to their group. After the drawing was completed, each individual explained to his group what his particular drawing represented. Later, the two groups discussed which group's drawing they felt was best and explained why. The Ss in the control group engaged in the same activity, except that no patients were present and the activity was held on the campus. After completing the group drawing exercise, the post-test measures were obtained.

Measuring Instruments

Opinions About Mental Illness (OMI): This scale was developed by Cohen & Struening (1962) on the basis of factor analysis and consists of 51 Likert-type items which assess the following five attitudes toward mental patients and mental illness: 1) Authoritarianism -- a high score for this attitude indicates that mental patients are perceived as an inferior class requiring coercive handling; 2) Unsophisticated Benevolence -- the higher the score, the stronger is the feeling that mental patients should be treated kindly but paternalistically; 3) Mental Hygiene Ideology -- high scores reflect humanitarianism, "tendermindedness," and acceptance of the belief that mental illness can be treated successfully; 4) Social Restrictiveness -- high scores indicate the belief that the mental patient is a threat to society, particularly the family, and must therefore be closely restricted in his activities both during and after hospitalization; 5) Interpersonal Etiology -- the higher score reflects agreement that unhealthy interpersonal relationships are basic forerunners of mental illness.

Social Distance Scale (SD): This scale was developed by Whatley (1959) and consists of eight Likert-type items. Higher scores indicate a greater tendency to avoid contacts with ex-mental patients.

Procedure

Ss were randomly assigned to four experimental groups and two control groups in a Modified Solomon 4-group design (Campbell & Stanley, 1963) so that both the main effects of conditions (pretested-not pretested) and the interaction of Conditions X Settings were determinable. All groups received posttesting with the OMI and the SD. Two of the experimental groups were scheduled for a two-hour encounter with the patients in the community setting (CS); one of the CS groups received pretesting with the OMI and the SD. The other two experimental groups were scheduled for a two-hour encounter with the same patients in the hospital setting (HS); one of the HS groups received pretesting with the OMI and the SD. The remaining two groups served as controls, having no encounter with patients; finally, one of the control goups received pretesting with the OMI and the SD.

All pretest materials were collected from Ss before departure by bus to their particular setting (CS, HS, or control setting). Posttesting for experimental groups was carried out while returning to the campus on the bus after Ss completed the two hour encounter with the patients. Posttesting for control groups was carried out after one hour of group activity which was essentially the same activity engaged in by patients and experimental groups, with the exception that in the control groups the patients were not present and the activity took place in a classroom on the campus of the University of Houston.

Thus, the procedure allowed the separation of the effects of testing from the possible effects of treatment (settings). It was hypothesized that Ss in the community setting would report more favorable attitudes toward mental patients than Ss in either the hospital setting or the control group.

Results

Six separate 2 X 3 analyses of variance (Winer, 1962) were performed with the posttest scores; one 2 X 3 analysis of variance of posttest scores for each of the five attitude scores from the OMI (Authoritarianism, Unsophisticated Benevolence, etc.), and one 2 X 3 analysis of variance of posttest scores from the Social Distance Scale. A fine-grained analysis of the differences in posttest scores between settings for the six attitudes was carried out by means of t-tests (Ostle, 1963) in order to determine whether the community setting produced greater differences in the predicted direction in Ss' attitudes than did the hospital setting or the control group experience.

Analysis of variance indicated that the effect of conditions (pretesting or no pretesting) was not significant in any case. Therefore, it was concluded that pretesting had no special sensitizing effect on posttest scores, and that the differences found between groups can be assumed to be due to treatment effect rather than to the effects of pretesting.

The F-value for the posttest scores on Unsophisticated Benevolence approached significance for settings at the .10 level. In addition, the F-value for Social Restrictiveness attained significance on posttest scores for settings at the .05 level.

Posttest scores on the other four attitudes were not significant beyond the .05 level for treatments, conditions, or for the interaction of Conditions X Treatments.

Unsophisticated Benevolence

As shown in Table 1, specific comparisons of posttest means by t-tests on the attitude of Benevolence indicate that the differences are in the predicted direction. Ss gave significantly higher (more favorable) scores on Unsophisticated Benevolence after experience with patients in the community setting than did those Ss participating in the control group. There were no significant differences between the means of Ss assigned to hospital setting and control group conditions. Although pretest scores also show a difference between Ss assigned to the community setting condition and those assigned to the control group condition, application of Dunnett's t-statistic (Winer, 1962), which is appropriate when a level of significance is desired for a set of all comparisons between several treatments and a control group, indicated that in the case of the pretest means the t-value did not reach significance, and must be regarded as due to chance. However, in the case of the posttest means, the t-value between the control and the community setting groups did reach the level of signifi-

Table 1
Means and T-Tests for Pre and Posttest Scores
on the Unsophisticated Benevolence Scale

Setting	Pretest Mean	Posttest Mean
Control	46.917	47.208*
HS	49.667	50.292
CS	51.250	51.208*

*p<.025 (t=2.11, df=46, one-tailed)

cance (1.95, df=66 for 3 treatments) required by Dunnett's t-statistic, and therefore, it was concluded that the observed difference was not due to chance. Thus t-tests confirm the hypothesis that Ss in the community setting will show a significantly greater tendency to report benevolent attitudes toward psychiatric patients than will Ss participating in a control group. No differences were observed between the HS group and the control group.

Social Restrictiveness

As can be seen in Table 2, the t-value between the community setting posttest mean and the control group posttest mean exceeded the .01 level of significance.

Table 2
Means and T-Tests Between Means for Posttest Scores on the Social Restrictiveness Scale

Setting	Pretest Mean	Posttest Mean
Control	22.500	21.542*
HS	23.333	19.500
CS	20.250	17.458*

*p<.05 (t=2.67, df=46, one-tailed)

There were no significant differences observed between setting means for the pretest scores. Thus, it was concluded that Ss in the community setting showed a significantly lower tendency to perceive patients as a threat to society, necessitating close restriction of their activities than did Ss in the control group. There were no significant differences between means for the hospital setting and the control group.

Negative Findings

The finding of no significant differences in attitudes toward mental patients after a brief encounter with patients in a hospital setting contradicts the findings of Chinsky and Rappaport (1970), Gelfand and Ullman (1961), Johannsen, Redel, and Engel (1964), and Lewis and Cleveland (1966), who found that contact with patients in a hospital setting typically contributed to more favorable attitudes toward mental patients and mental illness. Brevity of contact provides a plausible explanation as to why no significant differences were observed between Ss' scores in the hospital setting and Ss' scores in the control group condition since in the previous studies, the length of S-patient contact was much greater than in the present study. However, brevity of contact alone does not explain why Ss in the community setting condition reported significantly more favorable attitudes on two of the OMI factors, but not on the others. The lack of significant differences between scores of Ss assigned to the community setting condition and scores of Ss assigned to the control group condition on the attitudes of Authoritarianism, Mental Hygiene Ideology, and Interpersonal Etiology was assumed to be due to the non-relatedness of the experience to these specific attitudes. Previous research (Pryer, Distefano, and Marr, 1969) utilizing the OMI has shown that changes in the attitudes of Mental Hygiene Ideology and Interpersonal Etiology are more consistently related to training than to practical experience or contact with mental patients. Previous research (Metzer & Smothers, 1967; Pryer, Distefano, and Marr, 1969) has also indicated that the factor of Authoritarianism is much more closely related to basic personality than to either experience with patients or training.

Discussion

The results of the present study indicate that the treatment setting can have a significant effect on attitudes toward mental patients and mental illness. It was found that encountering patients in the community setting contributed to significantly more benevolent and less socially restrictive attitudes toward mental patients and mental illness, while a similar encounter with the same patients in the hospital setting had no apparent impact on Ss' attitudes.

There are several theoretical interpretations which can be made of the present findings. The basic premise of Helson's (1964) adaptation-level theory is that an individual's attitudes, values, judgments of physical, aesthetic and symbolic objects, learning and interpersonal relations all represent modes of adaptation to the environmental and organismic forces. Stimuli are seen as impinging upon organisms already adapted to what has gone on before, and internal states depend upon previously existing internal conditions as well as external stimuli. Helson divided all sensory experiences into three classes of stimuli: focal, background, and residual stimuli. Focal stimuli represent those aspects of the immediate environment which capture the major portion of the organism's attention and have the greatest influence on his behavior. The background stimuli represent those aspects of the environment which surround the focal stimuli. The residual stimuli represent the individual characteristics, internal states, sets, etc., which the individual brings to a situation. According to Helson, the pooled effect of these three classes of stimuli determines the adaptation level underlying all forms of behavior.

In the present study, the two locations (HS and CS) where Ss encountered the patients can be differentiated as separate behavior settings on the basis of Barker's (1968) essential attributes of behavior settings. The focal stimuli in both the community and the hospital settings was the group drawing activity. Therefore, it can be said that the focal stimuli were standardized across settings since the group drawing activity captured the major portion of both the Ss' and patients' attention in both settings. In addition, the individual characteristics of the patients were standardized across settings since the same patients served as target persons in both settings. Further, the Ss were randomly assigned to the settings. Therefore, it can be said that the residual stimuli attributable to the patients were standardized across settings and that the residual stimuli associated with the Ss were randomly distributed across settings. The only class of stimuli that was systematically varied was the background stimuli which consisted of the hospital environment for two of the experimental groups and the community environment for the other two experimental groups. Therefore, the differences observed in Ss' behavior (reported opinions about mental illness) can clearly be attributed to the differences in background stimuli between the hospital environment and the community environment. The present finding of differences in Ss' attitudes in the community setting but not in the hospital setting can be interpreted in terms of Helson's model in that the background stimuli of the hospital setting were apparently close enough to the Ss' level of adaptation (expectation) so that no pressure or force existed to influence them to change their attitudes. However, the background stimuli in the community setting were apparently dissimilar enough from what the Ss expected to find so that they had to alter their level of adaptation (change their attitudes) in order to adjust to the unfamiliar experience of finding mental patients in a community setting. Following the above reasoning, it is not surprising that Ss in the community setting reported significantly lower scores on the attitude of Social Restrictiveness than Ss in the control group, since one very basic aspect of the community setting was an absence of restriction-signalling background stimuli.

The results of the present investigation may also be interpreted in terms of Wicker's (1970) notion of behavior-environment congruence. Wicker applies the operant learning model to the idea of behavior-environment congruence and argues that through attending to certain environmental cues, or discriminative stimuli, people are able to establish standards of behavior which are appropriate to the socio-physical environment (setting), and thereby obtain positive reinforcement and avoid negative reinforcement. In other words, each socio-physical environment, or behavior setting, contains certain environmental cues which signal the type of behavior expected of the occupants.

In the present study it was argued that the hospital setting contains certain environmental cues (fences, differences in architecture from that of the surrounding community, zoning codes which separate the facility from the surrounding community, distinctively dressed staff and patients, restricted areas, signs restricting children, etc.) which are congruent with expectations of deviant behavior, whereas the community setting contains environmental cues congruent with expectations of non-deviant behavior. In this manner, Ss assigned to the hospital setting, upon entering the grounds, were cued to expect deviant behavior from the inhabitants, and therefore perceived the patients in an unfavorable light. Since the general public typically regards mental patients with fear, distrust, and dislike (Nunnally, 1961), and expects to find them in a restricted, deviancy-signalling environment, it was not surprising that Ss encountering patients in the hospital setting showed no significant difference in their post-encounter attitudes from posttest attitudes of Ss in the control group.

However, the community setting apparently contained fewer deviancy-signalling environmental cues, and Ss encountering the same patients in the community setting perceived them in a more positive manner (Benevolence), and saw them as less of a threat to the community (Social Restrictiveness).

The present study offers an example of how treatment environments can be altered in order to affect the public's perception of the inhabitants in a more favorable direction. The evidence suggests that the more the treatment environment is congruent with non-deviant behavior (contains fewer deviancy-signalling environmental cues), the more the public will regard the inhabitants with favorable attitudes. It seems ultimately more sensible to attack the problem of negative attitudes toward mental patients by modification of the deviancy-signalling environmental cues present in treatment settings, rather than to lay the burden of attitude change on the ex-mental patient or the mental health professional.

The data appear to support the shift in treatment setting from hospital to the community emphasized by the recent community health movement in that treatment facilities located in the community apparently contain fewer deviancy-signalling or restriction-signalling cues than does the traditional hospital setting. However, care must be taken in generalizing the findings of the present investigation to all hospital settings and all community settings since the present study focused on only one hospital setting and one community setting. Further comparative research should be done with a sample of hospital and community settings in order to verify the present pattern of findings. Perhaps community treatment facilities should be as similar as possible to the surrounding residential community in order to contain environmental cues congruent with non-deviant behavior and therefore, influence the public's perception of the inhabitants in a favorable manner.

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STUDENT REACTIONS TO CAMPUS PLANNING OPTIONS: A REGIONAL COMPARISON

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Campus master planning often takes place without much reference to the behavior, needs, or preferences of the students and faculty who will be chiefly affected by the planning decisions. We have attempted to fill part of this information hiatus by systematic inquiry at six widely separated colleges and universities.

More than 1000 respondents in New Hampshire, California, Indiana, Arizona, Ohio, and Pennsylvania have participated in our 247-item survey. They have indicated what they think about architectural styles, relationships among buildings, type of campus (rural, urban, etc.), type of housing, student union facilities, type of library, traffic patterns, parking, landscaping, shelter between buildings, and other matters of concern to campus planners.

A clear pattern of strong interest in campus design emerges from these data, among both students and faculty. Differences of opinion between these two groups, and regional differences, present complex problems for the designer. In general our respondents want a campus that is not too formal, not excessively "modern," not monotonous, not too expensive, not crowded, with buildings not too far apart, but also one that is varied in style (with continuity of design, however), set in a well planned landscape, with adequate (but unobtrusive) parking, and with related buildings close together.

Students want a warm, personal, varied, human-scale, esthetically pleasing campus, but they want good adminstration, minimum rules, excellent teaching, and careful use of funds, too. They consider technical matters such as air conditioning, heating, traffic control, and surface drainage important. Recreation areas, both indoors and out, are matters of concern to them, especially in relation to the idea of privacy for mixed socializing.

These are informed and thoughtful people. The abstract notion of beauty, in total campus planning, is not outside their scope, but they find it difficult to verbalize the factors that produce a beautiful campus environment. They are, however, quick to recognize poor decisions in planning and design, whenever such matters affect their own well being.

General Character of the Inquiry

Five years ago the Archonics Corporation (then Ewing Miller Associates, Architects, Engineers, and Planners) of Terre Haute, Indiana, was faced with many campus planning decisions for which there were no clear answers. Our investigations since then have been directed toward giving the campus planner a firm basis for making particular design choices. We have not attempted to be all-inclusive; we do not view the results of our work as a total study of campus design elements, relationships, or characteristics. We addressed ourselves to a few specific matters of special concern and urgency; we did not, for instance, develop any material related to the interiors of academic buildings, nor did we consider, except in the most general way, possible relationships between a campus and the surrounding area or community.

Our sampling procedure was nonrandom and nonsystematic. Wherever we knew a friendly dean, or some other person who could assist us, we asked for such help as we could get. For these reasons we view the present report as a pilot study and the results as suggestive rather than fully confirmed. The following table gives the number of respondents from whom we obtained completed survey forms on each campus; these figures represent a return rate in excess of 80%.

	Students			
Campus	Male	Female	Faculty	Total
1. Bowling Green State Univ., Ohio	72	93	20	185
2. California State College at Hayward	40	35	–	75
3. University of New Hampshire	73	67	–	140
4. Temple University, Pennsylvania	243	87	–	330
5. University of Arizona	44	29	–	73
6. University of Evansville, Indiana	76	105	63	244
TOTALS	548	416	83	1047

The six campuses were sampled at various times during the years 1967 through 1971. This was a period of dramatic change in attitudes among students, faculty, and administrators. We have no way of estimating how much these changes have affected the regional comparability of our information. Ideas about student housing, for instance, might shift rapidly when antipaternalistic concepts become fashionable on a given campus. Again, therefore, we urge caution in the interpretation of this study.

On the positive side, however, we note that more than 1000 people have given us their help by considering 245 carefully constructed survey items and that many of these respondents wrote copious replies to open-ended questions concerning what to include and what to avoid on a well planned campus. As an example of privately supported research for design purposes, we present our investigation without embarrassment; it has, indeed, provided insight with respect to many of the practical problems faced by the Archonics planners and will, perhaps, be useful to some of our colleagues.

Our method of surveying produces weighted relationships among many design factors in a given situation. Typically we employ a hierarchical structure of inquiry that gives us detailed information about clusters of related design components and then yields relative values among a series of such clusters. A single part of one of our surveys usually involves a list of options from among which the respondent picks one (or sometimes two) top choices and one (or two) low choices that represent, for him, items of greatest or least relevance in some particular sense specified in the instructions.

The scale value for each option, over a group of respondents, is that item's percentage share of all positive choices minus its percentage share of all negative choices. The resulting numbers are not directly comparable to scale values from other sets of items, unless standardized, but the relative strength of each item in a set is easy to read when these numbers are tabulated. Scale values near zero may be generated either by balanced differences of opinion or by low frequencies of response to an item, so we are careful to examine our data with these contingencies in mind.

We have found that our method is almost as reliable as the paired-comparison technique, is demonstrably better than the straight rank-order method (in the sense that respondents need not worry over borderline decisions), and is less time consuming than either. In practice we have observed that differences among crucial options have been clear and, at least in retrospect, logical; our use of statistical tests, therefore, has been minimal.

The following statements are an example of one set of options in the present study. Here we asked the respondent to mark a plus (+) next to the statement he agreed with most and a minus (-) next to the statement he agreed with least. For sets of more than ten items we have found that asking for two plus marks and two minus marks gives the respondent an easier job.

1. Landscaping money should be spent mostly for trees.
2. Landscaping should consist mostly of shrubbery and flowers.
3. Landscaping should include patios, benches, fountains, and decorative items such as bridges and winding paths.
4. Landscaping should be kept to a minimum; the money could be spent in better ways.
5. Landscaping should consist mostly of open lawn-areas.
6. Landscaping should include a lot of paved, bricked, or pebbled areas.
7. Landscaping doesn't affect one greatly; I don't pay much attention to things outdoors.

We also employed half-tone photographs to investigate preferences for several different architectural styles and schematic ground plans to examine opinions about relationships among buildings or about the arrangement of buildings in groups. For a few short sets of items we followed the common practice of asking the respondent to check one item in the set. A pair of fill-in questions concluded the survey and served a double function: respondents could blow off steam at this point and they could tell us about anything they felt we had overlooked. These two final items provided some of our most valuable information, when subjected to content analysis.

SURVEY RESULTS

Architectural Style

The eigth photographs in our survey gave respondents a reasonably wide choice among campus architectural styles: fake Georgian; fake Gothic; fake classic (bank-front, Greek-temple type); high-rise, precast-concrete modern; four-storey modern; modern two-storey, mostly-glass modern; and one-storey, California shake-roof modern. The pictures also contained such nonarchitectural variables as differential amounts of lawn area and greenery, different numbers of people in view, presence of water in one scene, presence of automobiles in another, and different times of year (bare trees versus trees in full leaf). These potential sources of variance could have affected our results in unknown ways and one survey (California State College at Hayward) did not include the eight building-style items. Real-life research, however, goes on despite such small obstacles.

and we present our data with the (pious) hope that the underlying differences have not been totally obscured by error of measurement.

The building that was two-storey, mostly-glass, irregular roof-line modern was a clear winner in four of the five available comparisions. The Bowling Green students, alone, preferred the neo-Georgian building slightly more than the mostly-glass modern one, although the difference was so small that a tied vote is implied. The same neo-Georgian example was a weak runner-up with the students at Arizona, New Hampshire, and Evansville. Temple students gave the California shake-roof building a weak second place.

The faculty at Evansville gave the neo-Gothic example first place, with the neo-Georgian a weak second. The Bowling Green faculty put the high-rise modern at the top of their list, closely followed by the mostly-glass modern.

At the low end of the response scale the Evansville students and faculty disliked the California shake-roof building, Arizona and New Hampshire students disliked the four-storey modern, and Temple and Bowling Green students disliked the neo-classic example. Bowling Green faculty disliked the neo-Georgian.

There is some evidence of male-female differences of opinion about campus architectural styles. We have six first or second place male-female comparisons available; for male students all of these were filled by modern examples, but among females three of the six went to the neo-Georgian building. The men and women were, however, in perfect agreement about what they disliked; at Arizona it was the four-storey modern, at Evansville the California shake-roof modern, and at Bowling Green the neo-classic. (Remaining male-female comparisons were not tabulated at the time of this writing.)

Can we draw any conclusions from all this, even tentative ones? Yes: there are regional differences in preference for various styles of campus architecture, there are student-faculty differences, and there are male-female differences. The implication for the planner or designer is that he must make some decision about which group he most wishes to please, or about which group he wishes to offend least (a more practical issue in many cases).

Low, High-Rise, or Mixed

We asked respondents to make one choice among low, spread-out buildings, or tall, high-rise buildings, or a mixture of low and high buildings, for campus architecture. The resulting percentages are instructive:

Campus	Percentage of Choices for Each Building Type: Low	High	Mixed
Arizona (s)*	9.9	12.3	77.8
New Hampshire (s)	19.4	2.2	78.4
Temple (s)	40.4	0.6	59.0
Evansville (s)	27.2	6.5	66.3
(f)	24.5	7.5	68.0
Cal. State Hayward (s)	16.0	8.0	76.0
Bowling Green (s)	10.3	4.2	85.4
(f)	15.8	5.3	78.9

*(s) = students, (f) = faculty

Though both male and female students strongly preferred the low-high mixture, on a relative basis the males favored low, spread-out buildings more than the females did. We note, for example, the relatively large percentage of preference for low buildings shown by the Temple respondents (243 male, 87 female).

From these data on building height it is clear that a mixture of low and high buildings will please a majority of people, both students and faculty, both male and female. But there is a strong, minority preference for low buildings. Again the planner must make a decision that will not please everyone.

Relationships Among Buildings

We asked respondents to make one plus choice and one minus choice among eight schematic patterns of buildings arranged in sets. The options were those shown in Figures 1 through 8.

The results, in terms of ranked preferences, are given in the following table:

Campus	Rank Preference (1 = Highest Preference) and Positive Scale Value: 1		2		3	
Arizona (s)	irregular	36	mall	29	contour	14
New Hampshire (s)	mall	29	irregular	26	contour	24
Temple (s)	mall	37	irregular	20	formal	6
Evansville (s)	line	23	mall	18	irregular	3
(f)	mall	48	contour	8	courtyard	5
Bowling Green (s)	mall	40	contour	12	irregular	10
(f)	mall	45	contour	30	irregular	10
Cal. State Hayward (s)	mall	34	contour	30	formal	9

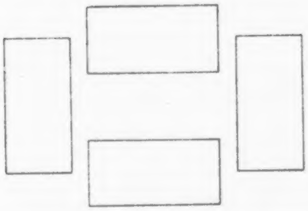

Fig. 1. Arranged around an open center or mall.

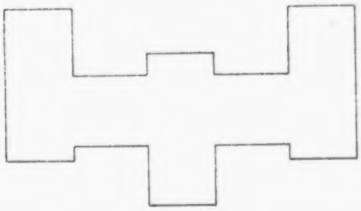

Fig. 5. Arranged as a single, solid unit or building.

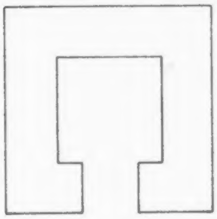

Fig. 2. Arranged around a courtyard as a single unit.

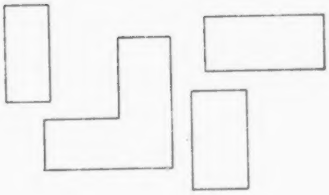

Fig. 6. Arranged irregularly, with no pattern.

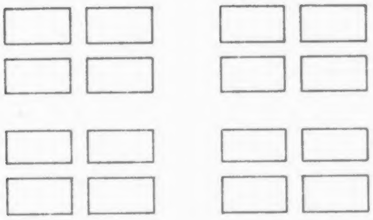

Fig. 3. Arranged by blocks, as in a city.

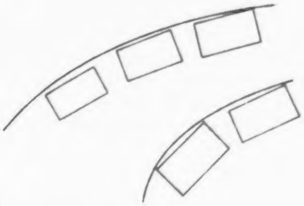

Fig. 7. Arranged to follow land contours or curves.

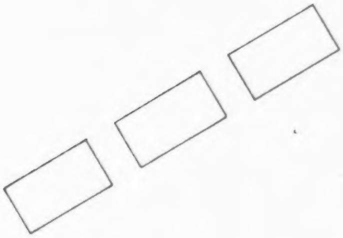

Fig. 4. Arranged in a straight line.

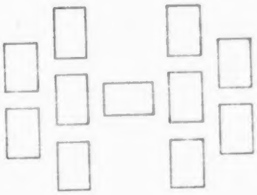

Fig. 8. Arranged in a formal pattern.

The arrangement in blocks, as in a city, was given the strongest negative vote in all comparisons except the one from the students at Hayward, who disliked the solid unit arrangement most, with the block pattern as runner-up. For all other comparisons the low-end runner-up was either the straight line or the solid unit option. Male-female preferences were negligible for this set of items.

In the sixteen first and second place positions the open center or mall pattern occurred eight times, the contour pattern four times, the irregular pattern three times, and the line arrangement once. A designer might, therefore, consider grouping buildings around malls, with the groups related to land contours, but with a few units showing little or no pattern relationship to the major clusters.

Such an arrangement, taken together with a mixture of low and high-rise buildings, would provide a high level of visual or spatial variety. We see no reason to doubt that variety, up to some unknown limit, is a much desired characteristic in the constructed environment today.

Landscaping Preferences

We asked people to make a positive and a negative choice within the set of seven landscape statements quoted earlier in this report. The major results can be summarized as follows (we ask the reader to augment this table by referring to the quoted statements):

	Rank Preference (1 = Highest Preference) and Positive Scale Value		
Campus	1	2	3
Arizona (s)	patios, etc. 56	trees 19	shrubs, flowers 11
New Hampshire (s)	patios, etc. 34	trees 31	lawns 9
Temple (s)	patios, etc. 21	lawns 18	trees 13
Evansville (s)	patios, etc. 40	trees 17	shrubs, flowers 7
(f)	trees 29	patios, etc. 20	shrubs, flowers 14
Bowling Green (s)	patios, etc. 37	lawns 10	shrubs, flowers 7
(f)	trees 32	patios, etc. 26	lawns 7
Cal. State Hayward	patios, etc. 50	trees 19	shrubs, flowers 3

Universally in lowest place was the statement that "Landscaping doesn't affect me greatly; I don't pay much attention to things outdoors." Next lowest, but not so unanimous, was the statement that "Landscaping should include a lot of paved, bricked, or pebbled areas." There were no male-female differences of any appreciable magnitude except that, on a relative basis, females preferred shrubbery and flowers more than males did; in fact the preponderantly male sample from Temple placed the shrub and flower option in the next to lowest position.

We conclude that landscaping characteristics are of considerable importance to both students and faculty and that a relatively clear pattern of values, more or less free of regional, sex, or faculty-student differences, can be observed in these results. Patios, benches, fountains, bridges, and winding paths are highly favored everywhere, with trees and lawn areas as strong second place items. Faculty might even favor trees above all other possibilities. Shrubbery and flowers are given a weak third place. Again we see that visual or spatial variety has a high positive value for most people; they even feel that money should be spent to provide this condition.

Vehicular Traffic on Campus

We asked six questions about roads, paths, and vehicles, by our statement option method. Respondents were to give one positive and one negative response.

1. Vehicular traffic doesn't bother me much; I don't mind cars on campus.
2. I like to walk without worrying about automobiles; they should be kept off campus.
3. There should be a minimum number of vehicular roads on campus and lots of pedestrian paths and walks.
4. There should be special paths for bicycles on campus.
5. Sidewalks and streets are still the most efficient way to handle traffic; we should stick to this method.
6. There should be pedestrian underpasses or overpasses wherever vehicular traffic is heavy on campus.

	Rank Preference (1 = Highest Preference) and Positive or Negative Scale Value		
Campus	1	2	3
Arizona (s)	minimum roads 33	no autos 7	bike paths 0
New Hampshire (s)	minimum roads 47	under-passes 7	bike paths −13
Temple (s)	minimum roads 30	no autos 14	under-passes 3
Evansville (s)	don't mind 32	minimum roads 25	sidewalks & streets − 1
(f)	minimum roads 52	sidewalks & streets 7	under-passes −10
Bowling Green (s)	minimum roads 34	don't mind 14	sidewalks & streets −10
(f)	minimum roads 50	no autos 30	under-passes −10
Cal.S. Hayward (s)	minimum roads 30	bike paths −2	sidewalks & streets − 5

At the two lowest positions on the negative end of the scale (e.g., -14, -22, -26, etc.) were the no auto option five times, the don't mind and the bike paths items four times each, and the sidewalk and street option three times. There were no substantial sex differences.

Here we have another example of similar preferences across regions, sexes, and academic status. Almost everyone wants to minimize vehicular traffic on campus, but we shall see later that this must be combined (as the students see it, at least) with plenty of student parking space. Keeping automobiles off campus entirely, however, is not a preferred solution for most people, though a considerable minority of our respondents did choose this option. Separate bicycle paths seem to be generally unwanted, and separating pedestrians from vehicular traffic by underpasses or overpasses has only a modest value for most of our respondents, although they do want plenty of pedestrian paths and walks.

Shelter Between Buildings

We asked six questions about shelter or lack of shelter between buildings and found, somewhat to our surprise, that people generally said either that they enjoyed being outdoors and unsheltered between classes or that they would accept being unsheltered between buildings if this would improve the appearance of the campus. A considerable number of students indicated, however, that they would use tunnels, if there were any, during bad weather.

Most students strongly disagreed with the idea that sheltered walkways are important even if they make the campus less pleasing in appearance. The faculty had an even stronger feeling; they said they disliked tunnels and would avoid them even in bad weather, while giving next to lowest position to the statement concerning the importance of sheltered walkways. Male-female differences were not conspicuous in this set of items.

Grouping of Buildings Versus Architectural Style

We asked four questions about the placement or grouping of functionally related buildings, but in this set of items we also placed two options dealing with architectural style. We wanted to see whether the grouping or the style factors would seem more important to our respondents. It is a little difficult to interpret mixtures of this kind, but we wanted to try the technique. The items were:

1. The library, Student Union, campus theatre, and other general centers, should be in the middle of the campus at an easy distance from everything else.
2. Buildings belonging to related departments or divisions (such as Arts and Sciences, or Business, or Education, etc.) should always be grouped close together to minimize travel time.
3. Residence halls and dormitories should be as close as possible to the academic buildings of the campus.
4. Residence halls are pleasanter to live in when they are some distance away from the academic buildings of the campus.
5. All campus buildings should be of the same architectural style, whenever this is possible.
6. Varied architectural styles make a campus more interesting and exciting; buildings all alike are monotonous.

For this set the results were, by item number, as follows:

Campus	Rank Preference (1 = Highest Preference) and Scale Value for Each Item					
	1	2	3	4	5	6
Arizona (s)	1; +40	2; +12	6; + 5	3; −16	5; −19	4; −22
New Hampshire (s)	1; +33	6; +21	2; +10	4; − 2	3; − 5	5; −56
Temple (s)	2; +38	6; +21	1; +19	3; − 7	4; − 11	5; −60
Evansville (s)	1; +26	2; +23	6; + 2	3; − 4	4; − 14	5; −37
(f)	1; +44	2; +28	5; − 9	3; −12	6; −24	4; −26
Bowling Green (s)	1; +34	2; +15	6; +12	4; −10	3; −11	5; −47
(f)	2; +40	1; +30	6; +25	3; −15	4; −15	5; −65
Cal. State Hayward (s)	1; +48	6; +19	2; + 8	4; − 6	3; −24	5; −46

From this table we see that people want general-function centers to be near the middle of the campus, and buildings of related departments to be grouped close together. In general, they also feel that varied architectural styles are important, perhaps as important as proper grouping of buildings, especially in view of the strong negative response to the idea that all buildings should be alike in style. People also tend to disagree with the idea that residence halls are better when they are not too near the academic part of the campus. Sex differences were not great in this set of items.

Urban, Rural, or Small-Town Campus

We found, in a set of five options, that almost everyone prefers a campus that is in or near a small town, with the buildings spread out and the campus well landscaped. A strong second place was given to the country or rural campus with generous spaces, trees, wide lawns, and other advantages that come from having plenty of land.

The strongest negative position was almost universally filled by the statement, "I really like a city or urban campus best, with buildings conveniently close together and all the advantages of a city setting." Next to this, in negative scale value, was the idea that it doesn't really matter what a campus is like, if the teachers and educational facilities are good. Regional, sex, and student-faculty differences were negligible in this set of items; we were a little surprised at this.

A Large Set of Characteristics

At this point we have examined several clusters of items, each related to a small set of design factors. Now we can consider a 15-item set that helps us evaluate design factors across clusters. Respondents gave two plus and two minus replies in this set. The options were:

1. Excellent architectural style.
2. Minimum travel distances among all buildings.
3. Large, well-landscaped spaces between buildings.
4. Pedestrian walks or paths, free of vehicular traffic.
5. Plenty of parking space for students, arranged so this space does not spoil the beauty of the campus.
6. Plenty of parking space for students, near the buildings.
7. Being near a town or large suburban center.
8. Being in a city.
9. Plenty of roads and streets through the campus for automobiles, buses, and other vehicles.
10. Exclusion of automobiles, except service vehicles, from the campus.
11. Plenty of open lawns, trees, shrubbery, and wooded paths.
12. Buildings grouped according to division or school, so that travel time is minimized.
13. Impressive or beautiful view of campus from the surrounding area or community.
14. Everything arranged strictly in terms of efficiency for educational purposes.
15. A focal point or center of interest on campus, such as a tower or a large fountain.

Here we find, in general, that plenty of open lawns, trees, shrubbery, and wooded paths form the option that occurs most often in the first and second high-positive positions (#11). Next most preferred is the item representing plenty of student parking space, arranged so that it will not spoil the beauty of the campus (#5). The third ranking positive option concerns pedestrian walks and paths, free of vehicular traffic (#4), closely followed by, or intermingled with, the item dealing with the grouping of buildings according to division or school (#12).

At the negative end of the scale two items are virtually tied: being in a city (#8), and plenty of roads and streets through the campus (#9). These are closely followed by the idea that everything should be arranged strictly in terms of efficiency for educational purposes (#14). Exclusion of all automobiles (#10) and the presence of a focal point such as a tower or fountain (#15) also have conspicuous negative ratings.

Across five years and the breadth of the country these evaluations show remarkable consistency. Sex and student-faculty differences, also, are not large. We feel that our respondents have given us a clear picture of a set of values that can be of great use to campus planners and designers. It is not necessary to belabor the idea that our respondents want natural beauty and visual or spatial variety on their campuses, even ahead of educational efficiency. They want to minimize, but not eliminate, vehicular traffic, and they want functional groupings of buildings. Architectural style, being near a town or suburban center, and minimum travel distances among buildings are matters of small concern, relatively speaking. Student parking space is strongly desired only if it can be arranged in a way that will not spoil the beauty of the

	Rank Preference (1 = Highest Preference) and Scale Value for Each Item														
Campus	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Arizona (s)	11; +20	5; +13	4; +11	2; + 6	3; + 5	12; + 4	7; + 3	10; + 1	1; – 1	6; – 1	7; – 2	13; – 9	8; –11	14; –13	9; –23
New Hampshire (s)	11; +26	5; +12	4; +11	12; +11	1; + 5	3; + 4	2; + 3	6; + 2	7; + 2	10; – 1	15, – 5	13; – 7	9; –14	14; –15	8; –32
Temple (s)	5; +14	11; +12	4; + 9	12; + 9	2; + 7	6; + 5	3; + 2	1; + 1	7; + 1	10; + 0	13; – 6	15; – 9	14; –10	9; –15	8; –17
Evansville (s)	5; +18	11; +12	2; +11	12; + 9	7; + 7	6; + 6	4; + 3	3; + 1	1; + 0	15; – 4	13; – 5	9; –12	14; –13	10; –16	8; –17
(f)	12; +23	5; +12	4; + 8	3; + 8	11; + 6	1; + 5	2; + 5	7; + 1	13; – 3	6; – 4	10; – 4	14; –10	15; –11	8; –16	9; –19
Bowling Green (s)	11; +22	5; +11	4; + 7	12; + 7	6; + 5	3; + 5	2; + 4	7; + 3	1; – 0	15; – 0	13; – 5	9; –10	10; –11	14; –15	8; –22
(f)	11; +23	12; +18	5; +13	2; +10	4; + 8	10; + 7	1; + 5	3; + 3	13; – 3	7; – 3	6; 5	14; –13	15; –14	8; –24	9; –24
Cal. State Hayward (s)	11; +20	6; +10	2; + 4	3; + [illegible]	5; + 4	12; + 4	4; + 7	7; + 7	1; + 1	10; – 5	8; – 7	15; –11	13; –12	14; –15	9; –16

campus (compare the ranks of items 5 and 6). It does not, however, seem important to these respondents that the campus appear impressive from the surrounding area or community (item 13).

Remainder of Survey

Our inquiry has also produced data on the following matters: willingness to pay extra money for air conditioning in living quarters, type of housing most preferred, desired facilities within a student union building, most preferred type of library (central versus branch, etc.), outdoor recreation facilities, indoor recreation facilities, where people study, who they study with, commuting frequencies and styles, preferred eating arrangements and pay plans, and a large body of material concerning who uses what facilities and how often. All of this information is being prepared for a later report which will be available from Archonics Corporation.

Conclusions and Discussion

We have learned a great deal through the help of our respondents. Certain design decisions can now be made on the basis of the needs and desires of those who will be most affected by the plans we devise. We are not, however, under the impression that creative design can be concocted from survey results. Students and faculty members can tell us what they like and dislike, but they rarely provide us with new ideas or the means of moving into the realm of the possible. These matters are still the prime function of the creative designer. When he takes a step forward, and something original comes into existence, then and only then can we measure people's reactions to the new thing, but the people themselves are not usually the source of creative ideas. We have not and cannot survey the artist-planner-designer out of his own sphere of activity.

On the other hand, we can give the planner much information that will temper his flights of fancy, make his environmental manipulations more human and more humane, and even, perhaps, help him in his arguments with college presidents, boards of regents, and (should he ever talk to them) faculty members and students. For all these reasons we feel that careful behavioral research, though it be only of the survey kind, has high utility for the design professions.

And that might lead one to wonder what contribution a psychologist can actually make in furthering the goals of an architect. Our research work has centered chiefly on design problems, some specific to a single building or series of buildings, some as general as an entire campus. So let us discuss the psychologist's contribution by analyzing the design problem itself.

There are three basic parts to this problem, and for each of these there is an appropriate set of psychological techniques.

First, when a problem is presented, the designer tries to obtain exact information of certain kinds. He may ask, "How much money is there and what are the site characteristics?" But he must also ask, "What behavior is to occur in the constructed spaces?" He looks at cost limitations, site data, and functional requirements. These are the basic program contingencies.

Concerning the functional requirements, within the program contingencies, psychologists are specialists in observing and describing behavior in precise terms. When the planner needs to know what goes on in an office, a park, a school, a factory, a hospital, a home, or an urban region, so that he can design spaces that will enhance and support particular functions, behavioral scientists can help. They are trained to observe and categorize behavior in ways that will permit quantitative description. This is exactly what is needed for architectural progamming.

Controlled and quantified observation is, therefore, the first area in which psychology can be useful to designers.

Second, with the program contingencies in hand, the designer begins to make design choices. These include structural choices, esthetic choices, and decisions about spatial relationships. Here, indeed, we think the psychologist may ultimately make his major contribution to planning because this is where experimental techniques and methodology appear to be most needed. Here we should study the effects of changes in elements of the designed environment. What happens to behavior when illumination, or color, or texture, or sound damping, or traffic patterns, or space relationships are manipulated? What must we do to ensure that only the variable we are interested in is having an effect? What do we do about the fact that humans very often adapt to environmental stimuli, even bad ones, and are usually unaware of the variables that control their behavior?

Applications of the experimental method can help answer these questions, and they form a second large area in which psychology can make itself useful to architectural planners.

And third, while making design decisions, the planner asks himself or should ask himself, "Will the result be sound?" "Will it be pleasing?" "Will it work?" He is thinking in terms of structural standards, esthetic principles, and indices of efficiency and comfort. These are the major planning criteria that must be satisfied by the design.

With respect to such planning criteria, there are techniques in psychology that are of some value. If the designer wants to check the accuracy of his predictions about whether a finished design will be pleasing, or whether it will work, then he must, eventually, find out whether his results did, in fact, work and were, in fact, pleasing. He must go back and check up on the finished product and then apply the resulting information to his next set of predictions. Only so do we make any gain at all in solving design problems.

For such investigations, the behavioral scientist has developed correlational techniques that offer considerable promise. Surveys and questionnaires (when properly constructed); indices of efficiency, accuracy, and speed of behavior; evaluations of comfort or convenience--all these can be worked out to fit the designer's needs. Case studies in depth, field observations, journal records, film or television recording, computer aids and simulations--each can be adapted to the process of evaluating planning criteria.

Answering the question, "How good were my predictions?" is, thus, the third area in which psychology can be useful to designers.

So there you have a synopsis of appropriate methods: For programming functional requirements, we offer training in making quantified measurements of behavior; for selection of specific design choices, we can apply experimental techniques for evaluating particular design variables; and for the validation of planning criteria, we have surveys, case studies, and similar measurements.

13: RESIDENTIAL ENVIRONMENTS

THE PUBLIC HOUSING ENVIRONMENT: A FEW SURPRISES

Robert B. Bechtel

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ABSTRACT

Previous research in the urban low income housing environment showed that residents had little control over their behavioral resources when compared to residents of a small town. When behavior settings of a public housing project are compared to the small town and poor urban settings, several surprises develop. The environment of the public housing project is richer than that of the poor urban (but private) housing settings. Yet the lack of control over behavioral resources is even more severe in the public housing environment. The public housing environment seems to be an extreme case of where centralized management control has thwarted architectural, social and planning principles.

THE PUBLIC HOUSING ENVIRONMENT: A FEW SURPRISES[1]

A. Previous Research

In the EDRA II conference (Bechtel, 1970) a comparison was made between the small town environment described by Barker (1968) and Barker and Wright (1956) and two urban residential areas. The town population was about 750 and their behavior settings were compared to 130 residents of two poor inner-city housing areas of Kansas City, Missouri. One area was Black, the other white. The findings indicated that in terms of variety of behavior, the urban residents were exposed to three times as many kinds of behavior settings as were the small town residents. But when the leadership of residents was evaluated it was found that the small town residents had many more chances to control and lead their settings than the urban residents. In fact, the urban residents had very few opportunities to take a leadership role in their own environment. The technique of the behavior setting survey was then used on a public housing project.

B. The Public Housing Environment

Every large city has a public housing authority. There are 2,930 local housing authorities in the United States. Their job is to build and manage public housing. There are one million units of public housing in the country with approximately four million persons in residence.

This study reports the results of a behavior setting survey on 1,716 residents in 636 housing units in a large north central industrial city. The setting survey revealed 67 behavior settings over a six week period from December 20, 1970 through January 30, 1971.

The housing project was code-named Arrowhead. Average income of residents was $2,800. Sixty percent of the population were females. All residents are Black.

The site plan of Arrowhead is depicted in Figure 1 on the following page.

The large playground at A was originally planned to be the center of activity for the entire surrounding area. Notice the pathway that starts in the extreme southwest corner of the map runs directly into the playground, then continues beyond the settlement house (D) on the other side of the one way street. Although this playground was planned as the center of the site, a hurricane fence around it now blocks all pathways into the center so that anyone attempting to cross the project from the north or the south must do a considerable detour.

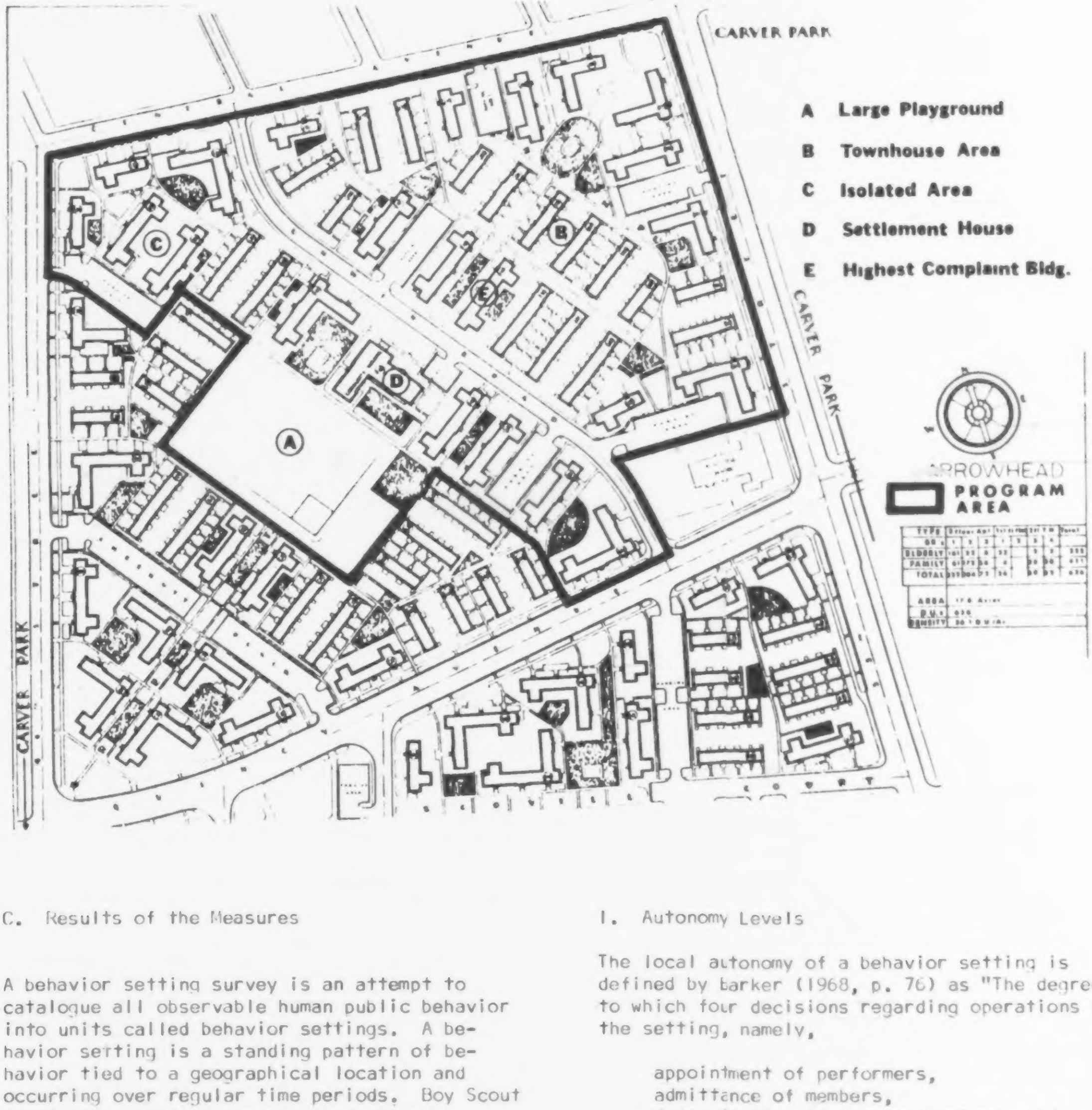
There are two types of buildings in Arrowhead. Three floor apartment houses are shown as either 'L' shaped buildings or shallow 'C' shaped buildings as at C. Two floor town houses are shown at B. Apartments are of brick construction, town houses of cement blocks. It should be pointed out that sidewalks connect to the kitchens of town houses. Town houses do not have sidewalks at the front living room door.

Slides shown here

The buildings of Arrowhead were first occupied in 1943 and have been occupied continuously since.

Figure 1

Complaint Zones


CARVER PARK
A Large Playground
B Townhouse Area
C Isolated Area
D Settlement House
E Highest Complaint Bldg.
A
B
C
D
E
CARVER PARK
CARVER PARK
ARROWHEAD
PROGRAM AREA

C. Results of the Measures

A behavior setting survey is an attempt to catalogue all observable human public behavior into units called behavior settings. A behavior setting is a standing pattern of behavior tied to a geographical location and occurring over regular time periods. Boy Scout meetings, school classrooms, and church services are behavior settings. But so are streets and sidewalks, newspaper deliveries, and playgrounds. All global behavior can be classified into settings.

Measures that accompany a behavior setting survey include 64 different kinds of scales. (See Barker, 1968) Only three of these measures will be reported here.

1. Autonomy Levels

The local autonomy of a behavior setting is defined by Barker (1968, p. 76) as "The degree to which four decisions regarding operations of the setting, namely,

appointment of performers,
admittance of members,
determination of fees and prices, and
establishment of programs and schedules

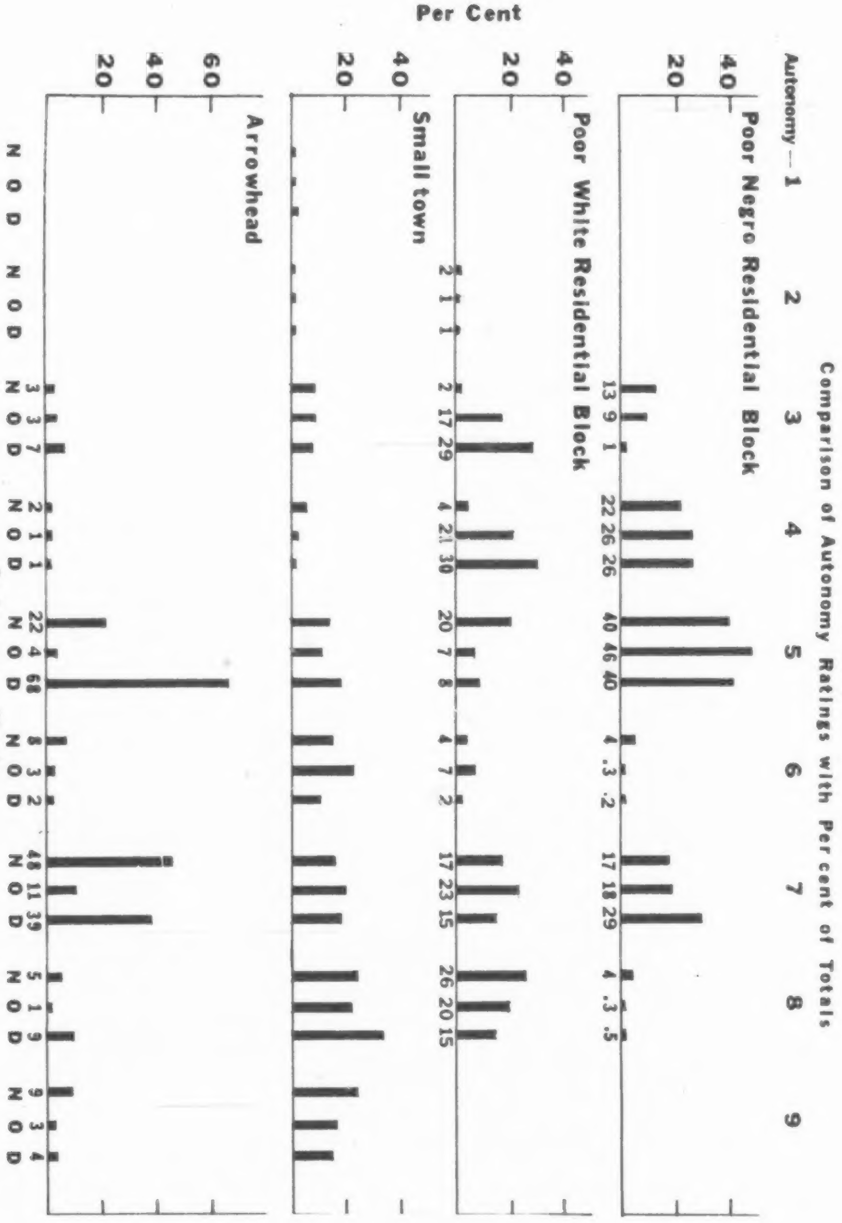
occur within five geographical areas with the differing proximities to the setting as follows:

within the town (8-9)
outside the town but within the school district (7)
outside the district but within the county (5)

outside the county but within the state (3)
outside the state but within the nation (1)"

Figure 2

Comparison of Autonomy Ratings with Percent of Totals



In the case of the public housing project, "Arrowhead" is substituted for town. Ratings are given in terms of number of settings (N), number of occurrences (O) and duration (D). Figure 2 compares the four environments. The most outstanding differences is the large percentage of duration of settings (68.4) at the 5 level which is the level at which the housing authority decides. Although the level is also high for the poor Negro area (46), it is significantly lower than for Arrowhead.

What these data mean are that an unusual amount of behavioral time is under the control of decisions made by the housing authority. The question arises as to how much of one's behavior, or the behavior of a whole group such as Arrowhead residents, can be under the control of others before the persons no longer consider themselves adults in our society? The Arrowhead environment is over-controlled by the housing authority.

2. Penetration Levels

Barker (1968, pages 49-52) defines six zones of penetration for every behavior setting that range from zone six, the single leader without which the setting would dissolve, through zone five, shared leadership, to zone four, the officer or functionary, to zone three, the bona fide member, to zone two, the audience, and, finally, zone one, the mere onlooker who adds nothing to the setting.

Zones of maximal penetration levels are usually at the five or six level simply because each setting almost always has a leader of some kind. The more useful measure, however, in looking at residential environments is to compare the maximal penetration levels available just to residents with the maximal zones of the settings as a whole.

Figure three shows the maximal penetration zones available to residents of the three environments reported in Bechtel (1970). It is obvious from these data that the two poor urban residential areas have little chance for leadership in their residential environments.

Figure four shows the maximal penetration zones available to residents of Arrowhead are mainly at the level of 3, membership, while the majority of settings, of course operate at the 5,6 level. This indicates, as in the poor white and Negro areas, that residents have little control over their environment. These data also confirm and add another dimension to the autonomy data.

Figure 3

Comparison of Maximal Penetration Levels with Penetration Levels Available to Residents in Three Environments

Maximal Penetration Levels

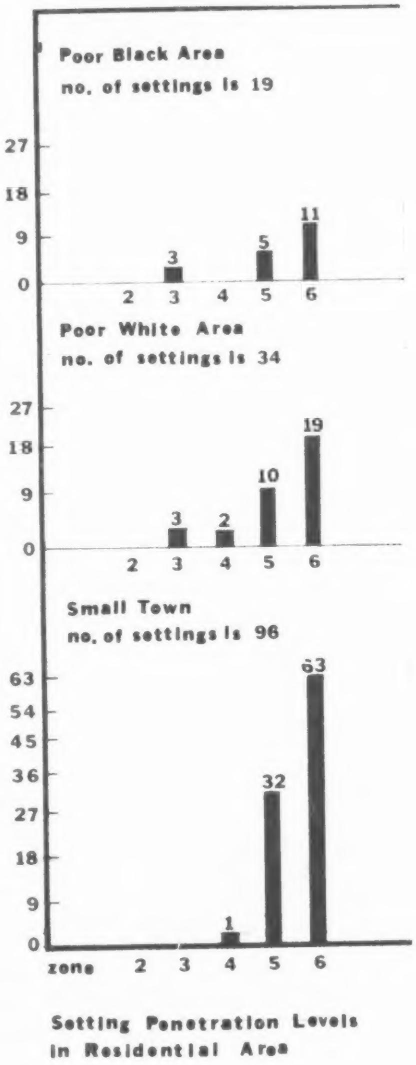
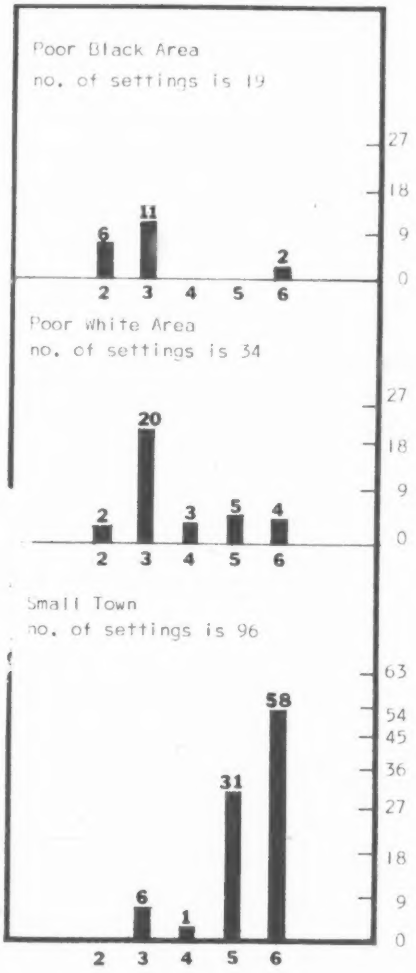


Figure 3 (Continued)



Penetration Levels of Settings Available Just to Residents

Figure 4

Maximal Penetration Zones for All Settings in Arrowhead Compared to Penetration Zones Available Just to Residents

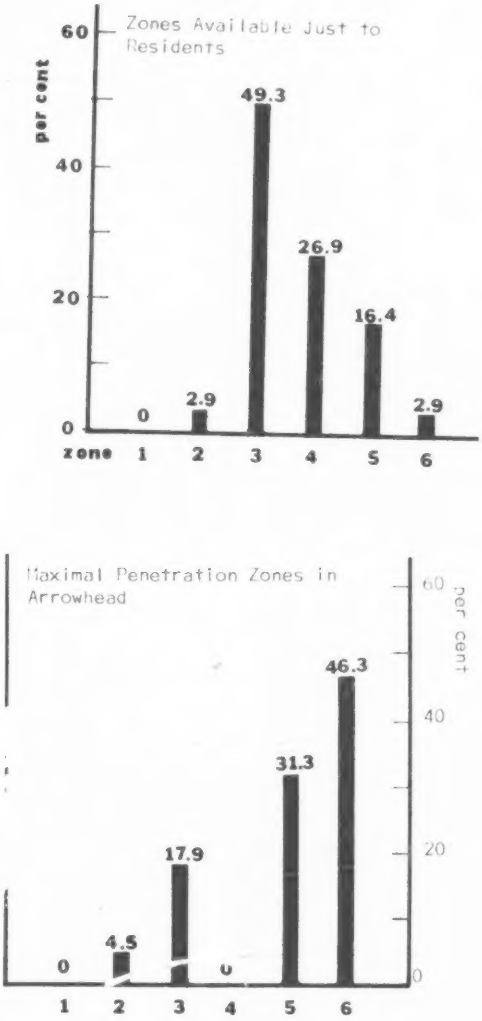
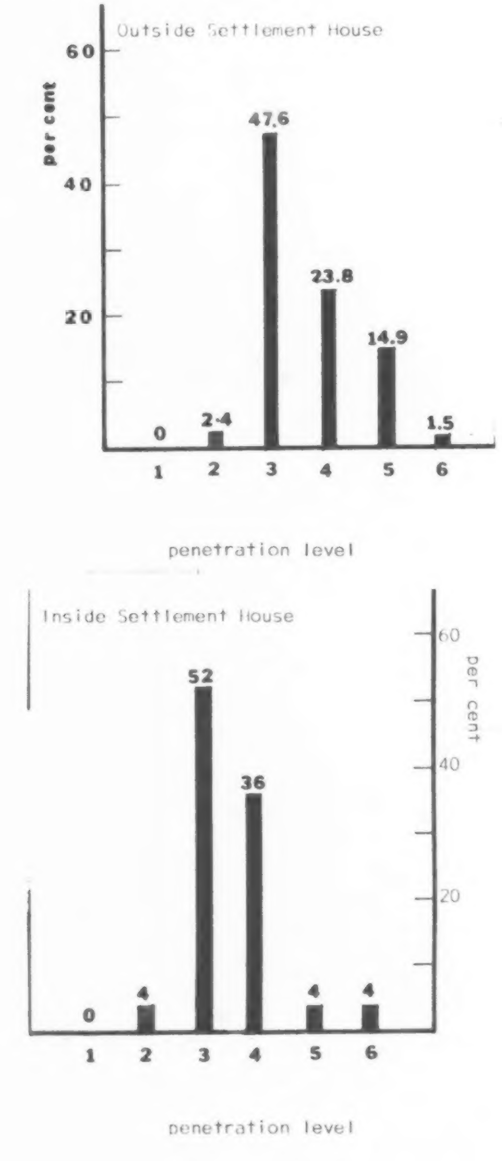


Figure five shows the environment of Arrowhead divided into those settings in the area outside the settlement house and those settings inside the settlement house.

Figure 5

Penetration Levels Open Just to Residents



It is clear that inside the settlement house established to serve them, Arrowhead residents have a little less control over settings than in the remainder of their own over-controlled environment.

These findings tend to confirm that services offered to poor residents, as in the poor urban private housing environments, do something to the resident rather than enlist his involvement.

3. General Richness Index

Barker (1968, page 70) says, "The richness of a behavior setting refers to the variety of behavior within its pattern of behavior." The index is computed by summing (a) penetration ratings of the population subgroups, (b) ratings of 11 action patterns, and (c) ratings of 5 behavior mechanisms and weighting the sum for the occupancy time for the setting.

The average general richness index for the settings in the poor white area is 7.88, for the poor Negro area, 5.19, and for Arrowhead, 8.54. Thus, it is clear that the variety of behavior within settings is far richer in Arrowhead than in the poor Negro area, and richer than the poor white area. Data are not comparable for the small town, but Arrowhead seems to compare favorably with it in terms of richness.

D. Conclusions For Public Housing

Arrowhead may or may not be typical of public housing environments in general. Certainly not all public housing residents are Black, but the majority are (62%) (HUD, OHM, 1971). 51% of Arrowhead residents lived there 5 years or more compared with about 54% with 5 years or more residence for all of public housing.

Yet there is good reason to believe that because of the uniformity of federal regulations on public housing and the increasing pressures toward centralized management because of increasing costs (de Leeuw, 1971) it is typical at least in regard to the over-controlled atmosphere. Further, the over-controlled aspect can be seen in the thwarting of site plan and architectural design. The construction of the large wire fence in the playground without regard to pathways, and the placing of sidewalks at kitchen entrances rather than front doors permanently memorializes the heavy hand of management in all decisions. According to poverty research, the Arrowhead area seems to exemplify a dependency atmosphere. Pareek (1970) describes dependency motivation in terms all too clear to the researchers who have been in contact with Arrowhead residents: (page 306)

"Dependency motivation can be characterized in terms of concern for control of decisions in power motivation, and it is expressed through lack of initiative, avoidance syndromes, (shifting responsibility to others, exaggerating obstacles), excessive fear of failure, seeking favors of superiors, over-conformity, and aggressive rejection of authority ('The so-called reverse reaction to dependency)."

While the solution, to restructure the management of Arrowhead to allow local decision making and leadership, is obvious, the findings raise fundamental issues about the rendering of all types of services to poor persons, and the old saw that "helping the poor" is a demeaning practice is amply illustrated.

E. The Use of Behavior Setting Data for Architecture and Planning

The Arrowhead study is a prime example of how a behavior setting survey with its wealth of detail can be applied to establish a groundwork for design solutions.

1. The behavior setting survey depicted a divided community. Figure 6 shows that the varieties of behavior are separated from each other and are not in behavioral proximity. The solution is to provide some structural way of allowing more behavioral intermingling.

2. The richness measure shows that the focal point of the community (Figure 6) was not the richest setting but that far-richer settings were isolated from the focal point. This means that Arrowhead needed to be reorganized socially and architecturally around a far richer focal point. The solution in this case was a commercial and service center constructed at the same location.

3. Other data show that the general participation level of all residents (penetration levels) is relatively low. Behavior setting theory (Barker and Gump, 1964) shows convincingly that large organizations and settings exert pressures not to participate at high levels, while small settings exert pressures to participate. The conclusion from data and theory is to break up the Arrowhead area into smaller social entities of around 200 to 300 people. Each of these areas would in turn be made up of a few buildings. The buildings would be supervised by a resident building superintendent who would act as a maintenance and semi-security person. This serves to break down the monolithic natures of both residents and management, but it also gives a basis for representation in social action groups, residents organizations, playground facilities, location of pathways and many other social and design decisions.

4. The richness of the nationalist marches and the cellars stands in direct contradiction to management policies. Security personnel are adamantly opposed to Black nationalist activities and the cellars are locked to keep out all residents except maintenance personnel. Yet the nationalist marches and the cellars provide residents with their richest behavioral resources. This is evidence that much of the natural behavior of residents cannot be regulated by external controls even when this is done for the seeming good of residents themselves. The cellars, for example, were closed because of security reasons, yet remain covertly open because they provide spaces that teenagers, prostitutes, and others want to use. The lesson is clear -- empty space will not stand unused in an environment where space is at a premium. A parallel is the use of vacant houses in crowded urban areas.

While the moral dilemmas of some of the uses of this space (in cellars) might indeed involve a basic restructuring of values in our society, the more obvious, and somewhat less controversial evidence is that the Arrowhead environment simply provides no areas where teenagers can gather outside adult supervision. The solution is to reopen the cellars in a semi-controlled manner with access supervised by the building superintendent.

F. The Building of a Community

The principles of behavior setting research and its attendant findings provide an abstract basis on which to build a community "from scratch" so to speak.

If one can imagine Figure 6 in its "ideal" form, the focal point would be the largest circle (richest) with the surrounding settings of decreasing size (richness). The varieties would also be more closely crowded (interdependent) among themselves. While not ideal, Barker and Wright's (1956) Town of Midwest approach this view (page 153, Figure 4.33). Perhaps even closer to the ideal would be the typical peasant village organized around a central square in which a majority of its activities take place.

While this abstract ideal may seem too pastoral for an urban society, some trends toward its realization are seen in shopping centers and new towns.

Figure 6

'ARROWHEAD' BEHAVIOUR-SETTING DIAGRAM

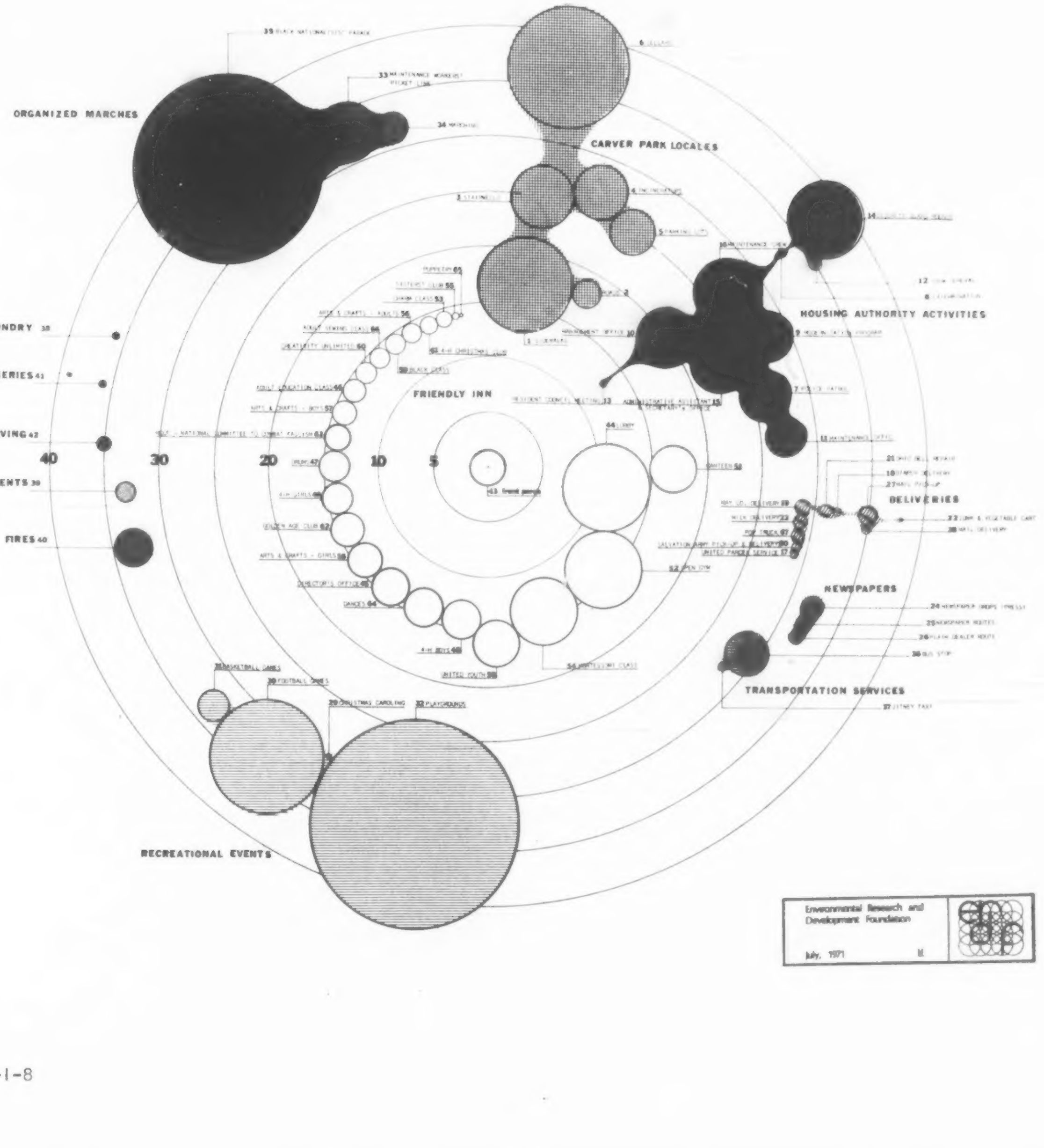
General Richness · Independence · Variety

Legend

Each setting is represented by a circle whose diameter is proportional to the GENERAL RICHNESS INDEX of the setting.

The distance of each setting from the core setting — the Friendly Inn front porch at the center of the diagram — is proportional to its INDEPENDENCE (K-value) from that setting.

The position of each setting is proximate to other settings belonging to the same VARIETY.



35 BLACK NATIONALISTS' PARADE
33 MAINTENANCE WORKERS' PICKET LINE
34 MARCHING
ORGANIZED MARCHES
6 CELLARS
CARVER PARK LOCALES
3 STAIRWELLS
4 INCINERATORS
5 PARKING LOTS
2
1 LOCKERS
14
16 MAINTENANCE CREW
12
8
HOUSING AUTHORITY ACTIVITIES
MANAGEMENT OFFICE 10
9
7 POLICE PATROL
RESIDENT COUNCIL MEETING 13
ADMINISTRATIVE ASSISTANT & SECRETARY'S OFFICE 15
11 MAINTENANCE OFFICE
PUPPETRY 65
SISTERS' CLUB 55
CHARM CLASS 53
ARTS & CRAFTS - ADULTS 56
ADULT SEWING CLASS 66
CREATIVITY UNLIMITED 60
63 4-H CHRISTMAS CLUB
50 BLACK DOTS
ADULT EDUCATION CLASS 46
ARTS & CRAFTS - BOYS 57
FRIENDLY INN
N.C.C.F. - NATIONAL COMMITTEE TO COMBAT FASCISM 61
LIBRARY 47
4-H GIRLS 49
GOLDEN AGE CLUB 62
ARTS & CRAFTS - GIRLS 58
DIRECTOR'S OFFICE 45
DANCES 64
4-H BOYS 48
UNITED YOUTH 59
54 MONTESSORI CLASS
52 OPEN GYM
44 LOBBY
CANTEEN 51
43 front porch
40
30
20
10
5
LAUNDRY 38
ROBBERIES 41
MOVING 42
ACCIDENTS 39
FIRES 40
21 DOOR BELL REPAIR
18 DIAPER DELIVERY
27 MAIL PICK-UP
DELIVERIES
MAY CO. DELIVERY 19
MILK DELIVERY 23
POP TRUCK 67
SALVATION ARMY PICK-UP & DELIVERY 20
UNITED PARCEL SERVICE 17
22 JUNK & VEGETABLE CART
28 MAIL DELIVERY
NEWSPAPERS
24 NEWSPAPER DROPS (PRESS)
25 NEWSPAPER ROUTES
26 PLAIN DEALER ROUTE
36 BUS STOP
TRANSPORTATION SERVICES
37 JITNEY TAXI
31 BASKETBALL GAMES
30 FOOTBALL GAMES
29 CHRISTMAS CAROLING
32 PLAYGROUNDS
RECREATIONAL EVENTS

Environmental Research and Development Foundation

July, 1971 II

Footnotes

1. Work on this project was done on contract No. H-1108 with the Cleveland Metropolitan Housing Authority.

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BEHAVIORAL MAPPING: THE ECOLOGY OF CHILD BEHAVIOR IN A PLANNED RESIDENTIAL SETTING

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Introduction

It is estimated that in the next forty years, as many new dwelling units as were built in the previous two centuries will be constructed in the United States. Recognizing this projected need, it becomes critical that designers understand man and his many relationships to the physical environment. At present, knowledge about man's technological relationship to the physical environment is more scientifically developed than knowledge dealing with his behavioral responses to it. Designers of man's environment have had little more to rely upon as a basis for their decisions than their own set of values which are often unrelated to those of the people for whom they design.

A behavioral orientation in environmental design is suggested not only for its promise of creating desirable physical environments, but also by an attitude within the design professions that the immediate physical environment profoundly influences psychological states and overt behavior. (1) The environment provides the opportunity for interaction and experience. It can be conceived of in terms of the probability that it provides for selected experiences or interactions. "Thus the environment which has a higher probability of providing certain experiences than another environment may be said to be a more powerful environment." (2)

The ecological approach provides a means for studying the spatial properties of human behavior. The objective is to describe behavioral phenomena as they occur in their natural setting. The methodological challenge is to keep the behavioral events free from intrusion, insuring that the observations recorded are reactions to the natural elements of the setting and not to the research techniques. This approach to the study of human behavior promises answers to the obvious initial question, "What does go on in designed environments?" It gives systematic consideration to the behavioral requirements of users of designed environments.

To analyze a designed environment ecologically, researchers must decide which activities are to be observed and develop procedures to record reliably and unobtrusively their occurrences, who performs them, where and when. In some studies, all activities for a given time period are recorded and later coded; (3) in other studies, a class of activities, (such as types of social interaction,) is observed by means of time sampling. The ecological approach has yielded initial information about what goes on in psychiatric wards, (5) nurseries, (6) university dormitories, (7) and libraries; (8) but thus far, only this small sample of the total array of traditional types of designed environments has been subjected to even a single environmental case study.

The Present Study

Objectives

As an exploratory attempt to test the techniques of unobtrusive measurement, an observational study was conducted in a planned residential environment. Theprimary objectives of this environmental case study of children's out-of-house behavior were methodological, focusing on:

1. the development of procedures to reliably and unobtrusively record the occurrence of observable human activity
2. the identification of relevant categories of information necessary to provide ecologically valid descriptions of observed behavior

In addition, since considerable attention had been devoted to the provision of "varied play spaces" for children, the project architects were particularly concerned with discovering the actual pattern of use made of outdoor play spaces.

This investigation, then, attempted to provide an empirical description of the nature and extent of use made of outdoor spaces by children. Specifically:

1. to identify and measure the spatial properties of observed activities and,
2. to identify and measure the behavioral attributes of spaces within the project boundaries.

Methodology

Geographical Setting

Ridgefield Park is a multi-family Turnkey I housing project located east of highway 15-501 in Chapel Hill, North Carolina. It is a racially homogeneous project (all black), containing 44 individual families, covering 8 acres of land and comprising a total population of 236 persons.

The site plan features staggered rows of attached single family dwelling units grouped around four parking lots, with all construction occurring on either side of a utilities easement that runs through the middle of the site. Each parking lot is joined to a dead-end street which connects the project with highway 15-501. Private sidewalks leading to each dwelling unit run off the public sidewalks that are around the perimeter of each parking lot. An internal pedestrian walkway connects each of the cul-de-sacs, providing vehicular-free passage through the project. Six different play areas are located along this walkway, each with wooden benches at or near their periphery. At the extreme eastern end of this pedestrian walkway, the community center, day care building, and the large community open space are located. The community open space has a basketball court, jungle gym, water spray, horseshoe pit, and a softball field.

The northern, eastern and southern edges of the project are bounded by wooded areas, with a creek running along the southern boundary. The western boundary is highway 15-501. There is a soccer field on the other side of the fence on the southern edge, and a white middle-class single family neighborhood to the north. A Shopping Center is within walking distance 1 mile north along highway 15-501.

Research Design

Observation Technique

In order to observe behavioral phenomena as they occur, intact, in their natural setting, it was necessary to pretest an observation route which allowed the observers to record activities before actually entering the physical setting. The site plan was divided into five zones along the dead-end street running through the project. As the observer's car entered each zone, behavior was observed and recorded at the moment of observation; changes occurring while the observer was still at a particular observation point were ignored. If the same child appeared later in another observation area he was noted again. Much of the project was not visible from the road so it was necessary to establish five additional observation zones along a walking route around the northern edge of the project. Each observation area was visited in strict rotation on each of the six observation days.

In order to eliminate the possible influence of extraneous factors on the number of children observed and the type of activity observed, observations were made systematically beginning at 4:30 p.m. and extending approximately to 5:30 p.m. on six non-rainy days in March and April, 1971. Four weekday and two Saturday observations were included over a two week period. The starting time was selected to provide time for children to arrive home from school.

The data recording sheet reports who performed each activity and where each was performed. In order to identify the location of observed behavior, corresponding numerals were noted on the data sheets and a map of the site. In addition to locational mapping, the site was described in terms of physical elements. These physical elements consisted of the following areas:

Physical Elements:

1. Front Stoop and Private Sidewalk
2. Backyard and Backyard Patio
3. Public Sidewalk
4. Street
5. Parking Lots
6. Woods
7. Public Open Space
8. Community Open Space

Observed behavior was described along two primary dimensions: Activity Type and Behavior Mechanism Rating. The Activity Type attempted to define the activity observed as accurately as possible. If objects played a dominant role in the activity, the activity was defined in terms of the object. If an object was used but wasn't dominant, the activity type was identified and the object was noted as an "object used." These activity types were later coded into ten categories:

Activity Types

1. Passive Play (observing, talking, reading)
2. Active Play (scuffling and gymnastic play)
3. General Play (exploring, camping, catching tadpoles)
4. Walking
5. Biking (with bicycles and/or tricycles)
6. Work (hanging wash, repairing car, sweeping)
7. Object Play (sticks, knives, jump rope)
8. Basketball
9. Ball Play
10. Horseshoes

The Behavior Mechanisms Rating describes behavior in terms of the following four dimensions: "gross motor," "manipulative," "verbal," and "affective," recorded as high, medium, low, or none in each observation. To obtain consistent ratings between different observers, pre-test observations were analyzed and discussed. Examples were also established to guide the rating decisions, but were never rigid. The "tempo" and "intensity" of each activity established its rating. In addition, the structure of each activity was described as "organized" or "unorganized" and "supervised" or "unsupervised."

The Participant Inventory identified the number of persons in an observation and their respective age, sex, and race. The ages of the participants were recorded as: infant (2 years and under); pre-school (3 years to 5 years); young child (6 years to 9 years); adolescent (10 years to 13 years); teenager (14 years to 18 years); and adult (19 and over). The number of persons recorded in an observation was later coded into "group size" categories. These categories are: one person; two to three persons; four to six persons; seven to twelve persons; and thirteen or more persons.

The pool of observations over the six-day behavioral mapping of Ridgefield Park shows the frequency of types of activity (in available locations.) The focus is on the behavioral properties of places, making the physical elements the independent variable and behavior the dependent variable.

The analysis of the dependent variable, behavior, can be conducted in two ways, with primary reference to: a) the characteristics of the activities, or b) the characteristics of the persons performing the activities.

Activities and Location

For analytic purposes, observed activity is described by its:

1. Behavioral Density. Behavioral Density measures the frequency of all types of activity at a place.
2. Behavioral Diversity Index. This index indicates the degree to which a place can be described as a diffuse setting. It is a ratio:
   Behavioral Density Index = $\frac{\text{Number of Activities Observed}}{\text{Number of different activity types}}$
3. Activity Type Profile. Any location in a designed environment possesses a behavioral character defined in part by the type of activities occurring within its boundaries. The activity types are based on the behavior mechanism ratings, organization and supervision profiles, and field note descriptions.
4. Group Size Profile. Groups are classified by the number of people involved.

Participants

The persons performing the activities are identified and described by their age group and sex.

Research Findings

Child Behavior and Developmental Level

In order to analyse child behavior it is important to understand how children mature and how their behavior differs at each stage of development. Maturation has been described as the development of innate potentialities in an ordered sequence. (9) Through play the child gains practice in performing activities which he will later be called on to perform in earnest. An important principle of maturation is that the impulse to perform some action precedes the use of that impulse for practical purposes. (10) Thus, it is to be expected that observed differences in the behavior of children result from differences in developmental level as well as differences in physical environment. The physical environment is the medium through which the potentialities of the child's nature are expressed and developed.

The first three years of life see the emergence of primitive instincts and potentialities and are largely concerned with the organization of the child's personality. (11) It is an age of dependence on the mother and the immediate environment.

The years from four to seven are years of individuality and self-assurance. (12) The child searches for development of his sense of power and proof of his worth. Although the child at this level is not engaged in social games in a true sense, he does require other children to play with which leads to sociability and cooperation. Gross motor activity is characteristic of group play.

The age from seven to twelve is an age of socialization, because children at this age like to join in corporate activities for a common purpose. Hadfield (13) terms this period the "primitive man" phase, because the child is interested in those activities associated with primitive life-camping, fishing, climbing trees. The child in the "primitive man" period subdues nature for his own ends. (14) Having previously developed his individual qualities, he now devotes his powers and abilities to the life of the group, which often forms with some common interest but soon disbands in search of other goals. (15) Because of socialization, the child of this phase is concerned with being like the others. As in the earlier phase, action is characteristic of play. Play separates along sex lines. (16)

Although adolescents (roughly ages 12-20) cannot be said to form a homogeneous group, it is possible to differentiate between adolescents and adults and to distinguish adolescents from children. (17) This period is characterized by rapid growth and a search for new experiences. At puberty, boys and girls tend to form gangs divided along sexual lines (18) with loyalty, respect, and admiration being characteristic. The adolescent has been likened to Lewin's "marginal man," by nature of his transitory condition and ambiguous status. He suffers from the "uncertainty of belongingness." (19) This lack of certainty about belonging, and the precarious self-esteem associated with it, seem to account for the adolescent's strong need to be with his peers. They attempt to form groups as a social anchor and basis for identity formation. This leads to strong group pressures and considerable conformity. In lower socioeconomic groups, the place in which face-to-face contact is made becomes invested with particular significance. (20) Adolescents arrive at their value systems through action, the success of which defines status. (21) Since the adolescent is under increasing pressure to act and to create a social position for himself among his peers, he becomes involved in socializing activities, often sports. (22) For the adolescent, "ties to class and family, to local community and region become more flexible and often expendable as more choices become available." (23) The importance of the peer group illustrates Linton's observation that there seems to be a universal tendency for members of all age-sex categories (other than infants) to develop some sense of solidarity, reflected in the ability of any one age-sex category to act as a unit when they feel threatened by any other age-sex grouping. (24)

Analysis of Data

Description of Observed Activity by Age, Sex, and Group Size: Based on the total occupancy of children in the project, young children are most frequently observed (93.3% of the children in the project of that age group were recorded). Pre-school children account for 81.0% while teen-agers represent the smallest percentage of reported age groups (29.8%). These findings suggest that the residential area provides a greater number of settings in which children up to the age of 12 can participate than it does for teenagers. It would seem that older children do find their local community "expendable" in favor of alternate gathering places.

Looking at the observations by group size, activity tends to be group-oriented, with groups of 2-3 being most often noted (38.7%), followed by groups of 4-6 persons (28.7%). Observations of individual persons are reported as only 19.3% of the total.

From an analysis of activity type by age and group size, passive play, most often general conversation and observation, is recorded most frequently (77.5%) in groups of 2 to 6 persons. Children aged 14-18 account for 56.3% of all such observations, suggesting the important socializing function of this activity for teens. Active play is seen most often (68.3%) in groups of 4-12 persons among children aged 6-13 (73.7%), reflecting the natural tendency toward vigorous gross motor activity characteristic of children in this phase of development.

Similarly, children aged 6-13 account for the major share (84.5%) of general play observations (exploring, hunting, camping) in 2- person groups (40.0%). This observation conforms to the characteristic group activities of children in the "primitive" man phase of development. Children 10-18 years old comprise 72.4% of all walking observations in groups of 2-3 persons (66.6%) with females noted most often (58.6%). This reflects the tendency for girls of this age to form more differentiated groups on a "best friend" basis. (25)

Bike riding, typical of younger children, is seen most often in 1-3 person groups (68.8%) in the 6-13 year old age group (77.8%). Teenagers (14-18 years) dominate the work activity, most often car repair and hanging wash (90.0%). Teenagers also dominate basketball play (62.2%). One person observations are seen most often (61.5%) in work, and 4-6 person groups noted most often (55.6%) in basketball observations. Object play is favored by 3-9 year olds (83.8%) in 2-6 person groups (81.8%), and ball play (kickball and catch) tends toward larger groups of 4 to 12 persons (80.0%) among children aged 6-9 years (55.6%). Horseshoe pitching is recorded most often among children 10-13 years old (96.6%) in groups of 4-12 persons (80.0%), indicating good spectator attendance and suggesting considerable socializing.

The Location of Activity

Summary Analysis of Data

The total frequency of all types of activities, or behavioral density (Table 1), is highest in the community open space where basketball, observing basketball play, general play and horse shoe pitching are dominant. The majority of children (70.5%) observed in the community open space are between the ages of 10 and 18 years (Table 2).

Most of the activity in the public open space (84.0%), second highest in behavioral density, is "active play" (Table 3). This is due primarily to play equipment, which promotes intensive activity. Almost one-half (46.7%) of the children observed are between the ages of 6 and 9 years while a little more than one-third (35.8%) are between the ages of 10 and 13 years. There is no difference between numbers of males and females. Most of the participants are in group sizes from 4 to 12 members (Table 4).

The parking lots, third in order of importance on the behavioral density continuum, are centers for teenagers and adults engaged in repairing or observing car repair and general conversation.

The most behaviorally diverse physical elements are the backyards and the street. They are also the least dense of all the physical elements. However, diversity is a ratio between behavioral density and number of activity types. A low ratio suggests a setting that is more ambiguous in terms of cues for certain types of

TABLE 1: BEHAVIORAL PROPERTIES OF PHYSICAL ELEMENTS

	A. Behavioral Density (Number of Observations) No.	%	B. Number of Activity Types	C. Behavioral Diversity Index A/B	D. Number of Children Observed
Front Stoop and Private Sidewalk	17	11.3	4	4.25	21
Backyard	12	8.0	5	2.40	20
Public Sidewalk	17	11.3	4	4.25	52
Street	9	6.0	3	3.00	18
Parking Lots	22	14.7	7	3.14	48
Woods	14	9.4	4	3.50	59
Public Open Space	25	16.6	5	5.00	128
Community Open Space	34	22.7	8	4.25	173

TABLE 2: PHYSICAL ELEMENTS AND AGE GROUPS

	Front Stoop and Private Sidewalk		Backyard and Backyard Patio		Public Sidewalk		Street		Parking Lots		Woods		Public Open Space		Community Open Space		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	Chi-square
Infant (under 2)	2	9.5	1	5.0	2	3.9	0	0.0	3	6.2	9	15.2	2	1.6	6	3.5	0.01
Preschool (3-5)	5	23.8	0	0.0	9	17.3	4	22.2	6	12.5	11	18.7	24	18.7	9	5.2	0.01
Young Child (6-9)	3	14.3	8	40.0	18	34.6	3	16.7	13	27.1	27	45.8	60	46.9	36	20.8	0.01
Adolescent (10-13)	5	23.8	7	35.0	1	1.9	10	55.6	6	12.5	9	15.2	33	35.8	62	35.8	0.01
Teenager (14-18)	6	28.6	4	20.0	22	42.3	1	5.5	20	41.7	3	5.1	9	7.0	60	34.7	0.01
Totals	21	100.0	20	100.0	52	100.0	18	100.0	48	100.0	59	100.0	128	100.0	173	100.0	0.01
Chi-square	ns		0.05		0.01		0.01		0.01		0.01		0.01		0.01		

TABLE 3: PHYSICAL ELEMENTS AND ACTIVITY TYPES

	Front Stoop and Private Sidewalk		Backyard		Public Sidewalk		Street		Parking Lots		Woods		Public Open Space		Community Open Space		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	Chi-square
Work	2	11.8	7	58.4	0	0.0	0	0.0	4	18.2	0	0.0	0	0.0	0	0.0	0.01
General Play	0	0.0	0	0.0	0	0.0	1	11.1	2	9.1	10	71.5	1	4.0	6	17.7	0.01
Biking	1	5.8	2	16.7	2	11.8	6	66.7	3	13.6	1	7.1	0	0.0	1	2.9	ns
Passive Activities	12	70.6	0	0.0	2	11.8	0	0.0	7	31.8	1	7.1	1	4.0	8	23.5	0.01
Walking	0	0.0	1	8.3	10	58.8	2	22.2	3	13.6	0	0.0	1	4.0	1	2.9	0.01
Basketball	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	9	26.5	0.01
Ballplay	0	0.0	1	8.3	0	0.0	0	0.0	1	4.6	0	0.0	1	4.9	2	5.9	ns
Object Play	2	11.8	1	8.3	3	17.6	0	0.0	2	9.1	2	14.3	0	0.0	1	2.9	ns
Horseshoes	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	14.7	0.01
Active Play	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	21	84.0	0.01
Totals	17	100.0	12	100.0	17	100.0	9	100.0	22	100.0	14	100.0	25	100.0	34	100.0	0.01
Chi-square	0.01		0.01		0.01		0.01		0.01		0.01		0.01		0.01		

TABLE 4: PHYSICAL ELEMENTS AND GROUP SIZE

	Front Stoop and Private Sidewalk		Backyard and Backyard Patio		Public Sidewalk		Street		Parking Lots		Woods		Public Open Space		Community Open Space	
No. Persons	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	6	35.3	7	58.3	1	5.9	4	44.4	4	18.2	3	21.4	3	12.0	1	2.9
2-3	7	41.2	3	25.0	9	57.9	4	44.4	12	52.5	6	42.9	7	28.0	10	29.4
4-6	4	23.5	2	16.7	6	35.3	1	11.2	4	18.2	4	28.6	8	32.0	14	41.2
7-12	0	0.0	0	0.0	1	5.9	0	0.0	2	0.1	1	7.1	6	24.0	7	20.6
13+	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	4.0	2	5.9
Totals	17	100.0	12	100.0	17	100.0	9	100.0	22	100.0	14	100.0	25	100.0	34	100.0

behavior and an expectancy of more diverse activities. Since the backyard is a part of the domain of the dwelling, the predominant activity observed (58.4%) is "work" with teenagers participating. Other activities include bicycle (ricycle) riding, object play and ball play. Young children account for a majority (40.0%) of the participants with no difference between the number of males or females observed. In this setting 58.3% of the observations consist of no more than one person. Bicycle riding and walking are the activities most frequently observed in the street. Adolescents occupy this setting most habitually (55.6%) in the single person group category (88.8%).

Site Plan Related to Activity Clusters

Current propositions advocated (26) suggest that ambiguous spaces bring out the investigatory reflex, allow for more creative behavior and permit unplanned behavior to occur, all of which are important ingredients for a "good" environment. While the physical characteristics of ambiguity are not clear, the contention is that a variety of cues suggesting a multiplicity of behaviors should exist rather than any dominant one.

This notion is at variance with the observations of actual behavior occurring, since the greatest behavioral density occurs in the community open space and public open space where the environmental cues (play facilities) are perceptible to the participants and suggest prescribed behaviors. (i.e., appropriate use of facilities).

The behavioral map (Figure 1) locates each of the 150 observations and represents the group size of each activity; the smallest circle represents one person and the largest represents groups of 13 or more participants. Based on spatial proximity twenty-two activity clusters have been identified (A-U). Clusters N through S represent the major activities occurring in the community open space. The design of the community open space represents the greatest single concentration of play facilities, expressing the intent of the designer to make the community open space a "center" of activity for the project. The distribution of recorded activities suggests a congruence between design and function, with over half (54.0%) of all observed behavior occurring in or within view of the community open space. In addition, 44.0% of the activities occurring in the public open space (second in behavioral density) have visual access to the center of activity in the basketball court, horseshoe pit area. Looking at activity clusters H and S, two jungle gyms: it can be seen that the jungle gym at cluster S, located nearer the basketball court area records a higher behavioral density, larger group sizes and a greater age group range. Also at this cluster are instances of teens supervising the play of younger children, reinforcing the observation that teens are more likely to be found near their peers. The "scarecrow swings" (cluster U) are also located adjacent to the basketball court area and are the next most used pieces of play equipment. Unlike activity at other equipment locations, (clusters G, H, J, and M) older children (10-13 years) are recorded most often, reflecting the characteristic age distribution at the nearby community open space. Activity in parking lots 3 and 4, which are adjacent to and in visual contact with the community space, is clearly influenced by proximal location. It is also noted that all activity in the parking lots (Table 3) is of a social nature with adults and teens dominating, indicating that parking lots serve their intended function as foci for neighboring activity. Two "bean stalks" are also provided; one (cluster M) located in visual contact with activity in the community open space, and the other located away from such contact. There are two observations at cluster M while there are no observations of activity at the other "bean stalk." Thus it seems that behavioral density in the community open space is related to a concentration of teen-oriented play facilities, and that intensive use of play equipment is clearly related to physical proximity and visual contact with this teen dominated "social center." Similarly, differences in the use of parking lots can be related to locational differences in regard to the community open space.

This pattern appears again in the public open space around cluster J, the merry-go-round. The age distribution associated with the use of this piece of equipment is predominantly 6-9 years (62.0%) of all the pieces of play equipment, the merry-go-round is most oriented towards the gross motor group play expected of this age group. The setting is clearly bounded and paved, with several benches located around its periphery, suggesting provision for group activity. Two major woods activity clusters (I and K) are located adjacent to the merry-go-round setting. Both are manned by 6-9 year olds, reflecting a tendency for all age-sex categories to develop some sense of solidarity, expressed here by spatial proximity. The socialization characteristic of the "primitive man" age group is evidenced in all three clusters with groups of 4 to 6 persons being observed most often (31.0%) followed by groups of 7 to 12 (23.2%). Of all woods play clusters noted, (clusters K, L and T) the cluster located adjacent to the merry-go-round records the greatest behavioraldensity and largest group sizes. The front stoop and public sidewalk observation occurring at location I also represent the greatest concentration of activity occurring anywhere on the site in those two physical elements. Thus, it seems that behavioral density at the merry-go-round is directly related to its preference by the dominant age group, and that adjacent concentrations of activity are influenced at least in

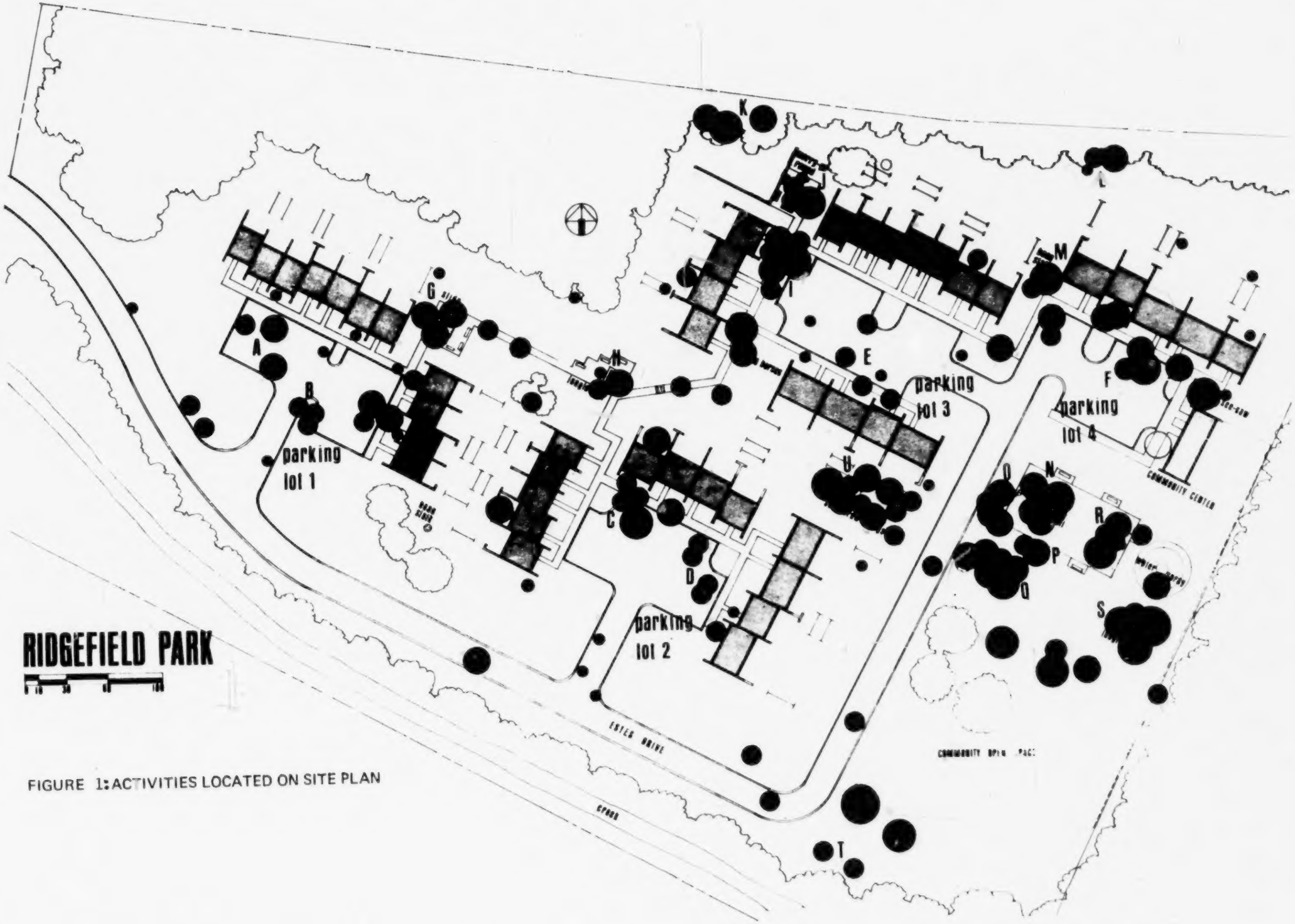
RIDGEFIELD PARK
A
B
C
D
E
F
G
H
I
K
L
M
N
O
P
Q
R
S
T
U
parking lot 1
parking lot 2
parking lot 3
parking lot 4
COMMUNITY CENTER
see-saw
COMMUNITY OPEN SPACE
ESTES DRIVE
creek

FIGURE 1: ACTIVITIES LOCATED ON SITE PLAN

part by proximity and visual contact with this second "social center." Congruence between design and use is again suggested.

The ambiguity concept is supported by the finding that the highest behavioral diversity occurs in settings that are more amgiguous (backyard and street) where the cues may be perceived differently bh the participants. Ambiguous spaces have been variously described as "unspecialized and unfinished" (27) and are characterized by a diversity of use. Certain devices have been advocated as allowing for such ambiguous qualities, including the provision of multi-use zones, and the provision for different uses at different times.(28) In addition to the high number of activity types observed in the backyard areas between 4:30 and 5:30 p.m., observers noted evidence of other uses at other times of day. Charcoal grills, lawn furniture, and play equipment were recorded as being stored in most of the backyards that faced away from major activity centers and toward the woods areas. The majority of activity in backyard areas is noted among these dwellings. Group sizes differ from the dominant pattern in other physical elements, with one person observations being noted most often (Table 2, Physical Elements and Age Groups). Similarly, the street activity is characterized by a predominance of one person observations. Thus, the physical elements noted as highest in behavioral diversity are multi-use settings manned most often by one person or 2-3 person groups.

Conclusions and Discussion

Though the data cannot be regarded as conclusive, it can be hypothesized that for children, behavior is more group than individual oriented. Also, the peer group of the child is so persuasive that structures are imposed on group play. Therefore, the selection of a setting for some group behavior is contingent upon the provision and perceptibility of environmental cues and the forms of behavior they suggest. Proximity to and visual contact with age-group dominated centers of activity also affects the intensity and distribution of group activity. A preference for diverse settings, however, would be more individually than group oriented and not predominantly influenced by group norms.

Clearly, site planning arrangements suggest certain appropriate behavior and the diversity of settings, both well articulated and ambiguous, allows for a wide range of expected and unexpected activities to occur. Although voluntary behavior is largely the result of the psychological habits of the individual, certain features of the non-psychological environment are perceived as appropriate to particular kinds of behavior. While parking lots and sidewalks suggest similar user behavior, there needs to be a common perception of the characteristics appropriate to certain actions. Yet perception of the attributes of size, material, boundary, etc., may or not be significant to the activities within parking lots and sidewalks. Local customs, acculturation and training are fundamental considerations of appropriateness.

Wicker, (29) in considering the processes which mediate behavior-environment congruence, discusses several psychological theories relevant to research in this area. The environment is conceived of in terms of Barker's behavior setting and the theories advocated attempt to answer the question, "Why do predictable, regular patterns of behavior occur within the boundaries of settings?"

The first theory which appears appropriate within the context of this present study is operant learning theory, in which some behaviors are reinforced in one situation while others are negatively reinforced in another situation. People are able to obtain positive and avoid negative reinforcements by attending to environmental cues, or "discriminative stimuli, (30) which are signals of the consequences which follow from certain acts. Any aspect of the environment which is perceptible is capable of becoming a discriminative stimulus if in its presence, certain responses lead to different consequences than the same response in its absence.

In this sense the jungle gym is a discriminative stimulus in which skillful manipulative and gross motor activity is required to avoid injury. Each of the pieces of play apparatus serves as a different discriminative stimulus to children of different ages. For example, to teens, the gymnastic apparatus signals behavior appropriate to younger children since teens are not seen at such equipment except in a role of supervising young children. It should be noted that any behavior-environment entity is rich in stimuli, involving physical objects, boundaries, people, and patterns of behavior within a bounded area, and any one or group of components can serve as a discriminative stimulus. However, the distribution of children suggests that certain physical objects serve as different stimuli to different age groups. Thus, the designer, in creating certain environmental cues, has at least partial effect on behaviors that occur within the designed environment.

The second applicable theory is a model formulated by Thiabaut and Kelly. (31) In this social exchange model, there are two criteria for determining the outcome of a given interaction: a) the comparison level, which is "the standard by which a person evaluates the rewards and costs of a given relationship in terms of what he feels he 'deserves'--based on all the outcomes known to the member, either by direct experience or symbolically," and b) the comparison level for alternatives, which is "the standard the member uses in decising whether to remain in or to leave the relationship, that is, "the lowest level of outcomes a member will accept in the light of 'available alternative opportunities." (32) Returning to Figure 2, the observation occupancy percentages for each age group can be reinterpreted in light of social exchange theory. Teens are notable by their absence, with only 29.8% of the children living in the project in that age group being observed. Based on the dynamics of social exchange theory it would seem that teens, being at an age that affords greater freedom, choose less frequently to be involved in project based relationships. The "available alternative opportunities" for face to face peer group interactions are preferable to those which the project setting provides. This is not the case among children aged 6-9 who are most frequently observed, with 93.3% of all children in that age group being recorded, nor among children aged 3-5 who report 81.0%. These younger children arelimited to the relationships available in the residential setting. Indeed, there are more facilities provided on the site which encourage participation by groups of younger children, suggesting congruence between design intent and behavior. Interracial observations are absent, although Ridgefield Park is located adjacent to a white neighborhood. In terms of this theory, this would suggest that the outcomes from playing with children of a different race in the project setting are below the children's comparison level for alternatives (play with children of the same race). Based on observed behavior, this notion of "available alternative opportunities" for different age groups has obvious implications for design decisions regarding site location and planning.

Evaluation and Suggestions for Further Research

It can be concluded that comparative observations of residential developments are needed, not only to suggest the importance of the existence of the spatial environment, but also to determine whether differences in these designed environments result in corresponding differences in behavior. Although observations in this study were recorded as of the moment of observation, it is apparent that future studies of this kind will require the use of time sampling observations to probe further into the relationships between activities and their spatial settings. Continued studies of this nature, especially in the neglected area of housing, will begin to provide designers with the kinds of behavioral knowledge that has been available to the social and physical sciences. At present, inferences can be drawn from the study described to similar or analogous problem solving situations in order to insure a better fit between man and his physical environment.

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THE PSYCHOLOGICAL ENVIRONMENT OF UNIVERSITY STUDENT RESIDENCES (1)

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Introduction

While the "environment" is generally considered to be pervasive and extraordinarily powerful influence on behavior, the exact specification of environmental or situational variables has been relatively neglected and, with the exception of the work of Barker (3), empirical attempts to specify environmental variables have, until recently, been notably absent. In the last few years a number of investigations have focused on certain delimited environments (4) including studies relating to personality, therapeutic behavior change, psychiatric ward environments (5), correctional facilities (6), high schools and high school classrooms (7).

University institutions have been the subject of a number of environmental studies designed to measure dimensions along which campuses vary and to relate there environmental characteristics to the psychological and intellectual development of students. The College Characteristics Index (CCI) (8) and the College and University Environment Scale (CUES) developed by Pace (9), were designed to measure the environment of colleges and universities by means of true-false questionnaires asking students about their activities and impressions of the college environment. More recently, Astin (10) has developed the Inventory of College Activities (CA) which covers four broad areas of environmental "stimuli"; peer, classroom, administrative and physical facilities.

While these measures represent notable advances in the assessment of environments and their impact on individuals particularly in educational environments, it appears quite clear that college environments are not monolithic and undifferentiated (9) but are composed of various sub-environments which may have considerable impact in themselves of students and also in the larger college environment.

One such important environment may be the immediate on-campus living residence (dormitory, fraternity, sorority, etc.) where students spend much of their non-classroom time and is the setting in which a large proportion of interpersonal learning and peer influence occur (11). For example, it may be that the immediate living environment (as distinguished from the general college environment) may have differential effects on students in areas such as satisfaction with college life, intellectual and academic productivity, and changes in subjective mood states and the development of psychiatric symptomatology. In order that these and other questions about the effect of the residential environment on students could be approached a scale was developed which attempts to measure both salient features of the residence environment and allows for the systematic comparison across a wide variety of living arrangements of varying collegiate settings.

Three methodological approaches can be utilized to measure residence environments. The ecological approach might include the measurement of residence size, sex ratio of residents, student to staff ratio, the number of one, two and three persons rooms, etc. A behavioral observation method might focus on types and frequency of various activities of residents such as amount of time spent together, the attendance at house social functions, types of behaviors at mealtime and house meetings, etc.

A third method, and the one employed in the present study, is logically similar to that used in the CCI (8), CUES (9), and the Ward Atmosphere Scale (12); this may be termed the perceptual approach. Students and staff are asked to describe the usual patterns of behavior in their living units and their perceptions of the house. While each person may perceive his environment in idiosyncratic ways, there is a point at which each individual's private world

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merges with that of others so that common interpretations of events tend to arise out of common experiences. It is this common consensual perception of the press of immediate environment which the University Residence Environment Scale (URES) was developed to measure.

Each of the approaches to the measurement of environments described above undoubtedly would yield important information about the climate of university residences, and would be expected to be moderately correlated with data obtained using other methods. The usefulness of the perceptual approach may in part be seen by noting that the press of the external environment (including the behavior of other persons and ecological variables) suggests the direction a resident's behavior must take if he is to function with a minimum of stress and a maximum of satisfaction within his particular living group. For example, a student's perception of the friendliness or hostility of the environment regarding certain behaviors will channel his behavior as a function these anticipated rewards and punishments possible in his living unit. These perceptions will in turn, direct him to various aspects of the environment such as particular groups or individuals in his dormitory who may through modeling and reinforcement processes, have an important impact on his subsequent attitudes, value orientations, intellectual curiosity and self evaluations.

Method

Two major questions were asked in the present study: 1) Does the psychological environment vary from one living environment to another, and can these differences be measured by the URES; 2) Can the psychological environment of a residence be described in relatively homogeneous ways by persons in that milieu?

Several methods were employed in obtaining the initial pool of questionnaire items and in gaining a naturalistic understanding of dormitory climates. First, meetings with groups of dormitory residents were arranged to talk about their perceptions of their individual houses and to discuss with them their likes, dislikes and general observations on dormitory living. These interviews consisted of 10-12 students and usually lasted for one to two hours. The format was informal and unstructured with the interviewer asking various questions about their unit to elicit the group's response and noting the replies and debates which sometimes resulted. Interviews were arranged in approximately 10 different dormitories ranging from freshmen through graduate and professional dormitories and consisting of both male, female, and coed dorms. Second, various environmental scales (e.g., the Moos WAS, Stern's CCI, Pace's CUES) were studied to generate additional ideas about items which might discriminate between university residences. Third, several books and articles were read in an effort to identify differing dormitory atmospheres and to understand dimensions along which university residences would vary. Lastly, observations by university housing personnel were solicited and the authors' own reminisences of their college experiences were scrutinized and wherever possible formalized into items.

The resulting form consisted of 274 items, including twenty items drawn from the Crowne-Marlow Social Desirability Scale were included to furnish a measure of the response set, and 16 items to measure positive and negative "halo" effects.

The questionnaire was given to both student and staff residents in 13 dormitories at a private university. These dormitories included male, female and coeducational houses, large and small units, and houses composed of students who were either exclusively freshmen, exclusively upperclassmen or all four undergraduate classes combined.

Revision of Preliminary URES

The first question of interest was to determine whether the items actually discriminated between the tested houses. One-way analyses of variance were computed among all 13 dormitories for each of the 238 environmental items (of the total 274 items 20 were Crowne-Marlow S.D. and 16 were "halo" items which were later dropped from the scale). Of these items 87.9 percent were significant beyond the .05 level with 199 or 83.6% of the total discriminating at the .01 level. Of the 238 environmental items 18 or 7.6% had significant ($p < .05$) correlations with the total Crowne-Marlow scale, indicating that item responses by subjects were not confounded by social desirability.

Since it appeared that measures of the perceived environment could significantly discriminate among different living units, the next step was to select items for a revised version of the scale. Criteria used in selecting items for the revised (R1) form were as follows. First, an item should signigicantly discriminate between the houses tested. Secondly, items should not have true-false response splits more extreme than 80%-20% to be descriptive of all residences. Third, each subscale should have 5 true keyed and 5 false keyed items so that acquiescent responding could be controlled. Lastly, items should not be correlated with the Crowne-Marlow scale.

These four criteria were applied to the item responses from the dormitory sample and resulted in a 140 item R1 form of the URES composed of 14 environmental subscales. Ninety-five percent (133) of the items significantly discriminated between residences and only 9 items had significant correlations with the Crowne-Marlow S.D. scale.

Each of the 14 subscales of the URES R1 version were then subjected to one way analyses of variance to determine if they could differentiate among the 13 dormitories. All 14 environmental subscales reliably differentiated among houses in the sample at highly significant statistical levels.

Revision of the URES R1 Form

The psychometric properties of the scale results from initial data collection and enthusiasm from feedback of results to dormitory residents and administrative personnel encouraged the authors to collect data on a larger number and wider range of student residences.

Subsequent to these data collections, the decision was made to revise the R1 version of the URES to: 1) reduce the total number of items in the scale, 2) reduce the content overlap and seeming redundancy of some items, and 3) to reduce the overlap among some subscales.

A random sample of students was chosen from each house in the norm group of 73 houses with selection being made to insure proportional sex and class representation within each floor of the residence. (Total revision sample N=505)

First, a factor analyses (VARIMAX rotation) was performed to provide information about possible item clustering other than the a priori method initially employed in defining the subscales. In general, the factors which emerged in this analysis closely paralleled the R1 subscales. Item intercorrelations, subscale intercorrelations and item-to-subscale correlations were than calculated for 3 successive trials with item deletion and subscale recomposition after each trial as indicated.

The subscales were reorganized using the criteria previously mentioned (i.e., reduction of item and subscale overlap; reduction of total scale length) and the additional ones of 1) high item-subscale correlation, and 2) maximum discrimination of items. This latter criterion was met by computing one way analyses of variance for each item across all 73 houses in the norm group and choosing items with the most significant F ratios. This procedure resulted in a 96 item URES (Form R2) grouped into 10 subscales (13). Table I presents the subscales and their definitions.

TABLE I

Subscales Composing the URES

Relationship Subscales: The emphasis on interpersonal relationships in the house.

Involvement: Measures the extent of interpersonal and house involvement felt in the house; also, the degree of friendliness and group cohesion and loyalty.

Support: The extent of general emotional support and the degree of emphasis on open honest communication.

Personal Growth: Subscales measuring psychosocial development of residents.

Independence: The stress placed on independent actions and thoughts versus more social proper and unformist climate in the house.

Traditional Social Orientation: The degree traditional dating and related behavior is stressed in the house.

Competition: (This subscale is a bridge between the personal and intellectual growth subscales.) Measures the degree to which a wide variety of activities (e.g., dating, grades, etc.) are cast into a competitive framework.

Intellectual Growth: Subscales measuring emphasis on academic and intellectual activities.
  Competition: As above.
  Academic Achievement: The degree of house climate emphasizeng grades and other formal academic accomplishments.
  Intellectuality: The emphasis on cultural, artistic and other intellectual activities not related to classroom achievement.

System Change and Maintenance: Subscales measuring the stability and possibility for change of the house environment from a system perspective.
  Order and Organization: The emphasis on rules, schedules and the following of established procedures.
  Innovation: Measures the degree of stress placed on novel activities and spontaneous events, both at the house level and between individual residents.
  Student Influence: The amount of control student residents perceive they have in the running of their house versus control by staff or administration.

The subscales are grouped into 4 categories: 1) The emphasis on interpersonal relationships, 2) the pressure toward change in emotional and psychological functioning, 3) the emphasis on intellectual and academic development, and 4) the emphasis on a rigid versus more fluid social organization.

Results

Subscale Discrimination

Each of the the URES subscales were subjected to one way analyses of variance across all 73 residences in the current norm group to determine whether they differentiated among these houses. All 10 subscales reliably and very significantly discriminated among houses in the sample. Thus, one of the major criterions of the scale construction has been achieved.

Reliability

The reliability of the URES Form R2 was estimated by employing internal consistency, test-retest and profile stability methods. KR20 correlations range between .772 and .879 and mean item-total correlations reveal that all of the subscales are composed of homogeneous items.

The temporal stability of individual perceptions was measured by administering URES to the same subjects on three separate occasions in one men's and one women's dormitory at a public university. The product-moment correlations reveal that individuals living in these two dormitories perceive their respective environments in similar ways both 1 week and 1 month after an initial testing. The correlations range from about .6 to .8 after 1 week and .5 to .7 after 1 month. While there is some decrease of the correlations from the 1 week to the 1 month testing, the drop off is quite small indicating adequate individual stability over a relatively long time period (11% of the academic year).

The third important reliability component for an environmental scale is the stability of subscale scores when the residence as a whole is the unit of measurement. The intra-class correlation was used to estimate profile stability 1 week and 1 month after the initial testing and reveal very great profile stabilities for the above two houses clustering around .90.

Intra-House Agreements

The homogeniety of living unit perceptions by persons within the house was approached by computing the percentage agreement for each subscale over the initial sample of 13 dormitories from a private university. For the 130 (13 houses by 10 subscales each) agreement rates 128 are greater than 70%. While some variation would be expected (and may even itself be indicaive of an environmental quality) a reasonably high degree of agreement by residents in a house should obtain and be reflected in environmental measurements. In general, the URES fares well on this criterion and reflects a high degree of consensus among residents (a similar method is presented by Pace (9) who used a 2/3 agreement criteria for scoring the CUES).

Residence Profiles

Profiles can be constructed which show the average perceptions of a residence group or any subgroup within a house.

Figure 1 presents the perceptions of student residents in 1 women's, 1 coed, and 1 men's dormitory, using the mean (50) and standard deviation (10) of the 73 house norm group as the frame of reference. Compared to the norm group, each of these houses stress relationship variables heavily except the women's house which is lower on involvement.

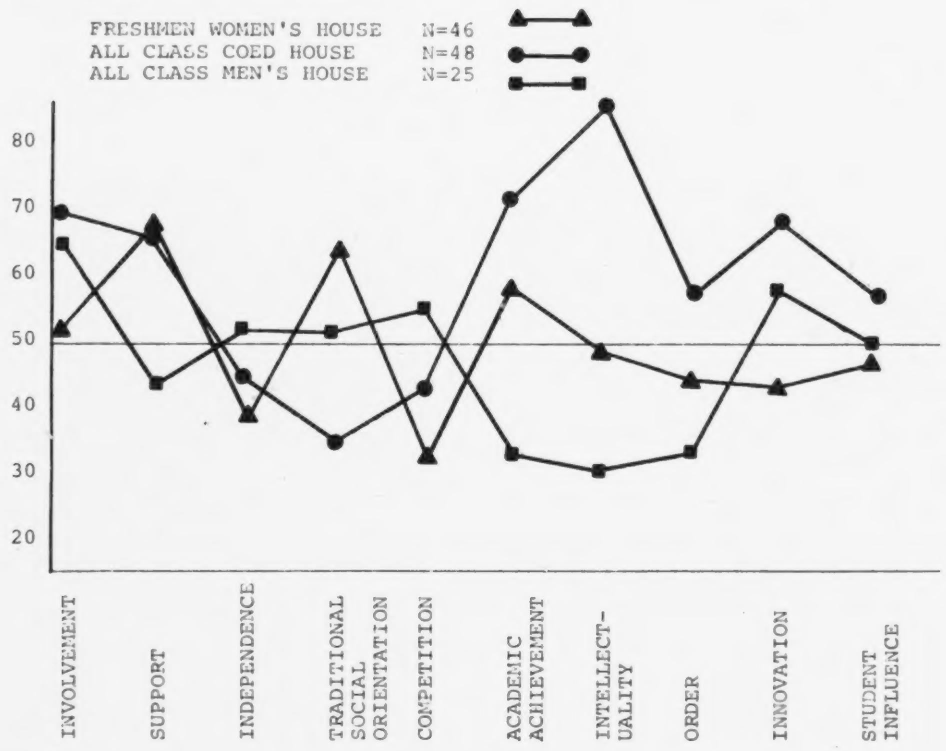

FIGURE 1

The personal growth areas generally show the coed house less concerned with traditional behavior, with the women's house stressing this variable. As could be anticipated the men's house stresses competition more highly than the other houses. Intellectual growth variables show the coed house emphasizing these areas very heavily while the other houses are either close to the norm group or below. Finally, system change and maintenance show the coed house balancing the two forces. The other houses do not seem to have a coherent orientation.

It is interesting to note that residents of the coed house perceive their environment as stressing personal concern, involvement, mutual support and a high degree of achievement. While this finding in itself may be significant in the assessment of these different living arrangements, a further important question is whether these environmental differences are due to pre-selection of student residents, the results of the living experience itself, or an interactive effect. Further studies are planned to elucidate this process.

Intra-House Comparisons

Within any residence various subgroups may perceive the environment differentially, and this may in turn influence the overall level of satisfaction or conflict in the house and provide clues to the locus of such strain. One example of such subgroup comparisons are the perceptions of male and female students living in the same coed residence. Other interesting comparisons could be made for students versus staff, senior versus freshman students, new versus old residents, etc. In a sample of three coed dormitories from one university, the men and women perceive the house environment almost identically. One factor contributing to the close congruence of perceptions in these three houses may be attributed to the fact that coed housing was in its fourth year at the university sampled and this may have allowed sufficient time for a set of "cultural" norms to be established and transmitted to new residents. Thus potential desparities of attitude, perceptions and behavior of both sexes could be accommodated within an overarching set of values. An alternative hypothesis is that students living in the relatively few coed houses then available on this campus were self selected and thus entered with similar expectations, etc., rather than these attitudes and perceptions being shaped by the living environment. It would be quite interesting to make similar comparisons at institutions that were in their first year of coed living arrangements where the student's housing choices are more restricted. Measurements of anxiety and tension within the house and behavioral indices of strain and conflict would be useful correlative data in examining subgroups within houses.

Comparison of Dormitories and Fraternities

An important use of the URES may be in comparing different residence philosophies as reflected in the type of programs and residence organizational structures developed at various institutions. Not only can the pervasive dormitory-fraternity dichotomy be compared as below, but also residences with various programs can be evaluated and contrasted to other such experiments.

Figure 2 presents the profiles of 1men's dorm and one fraternity.

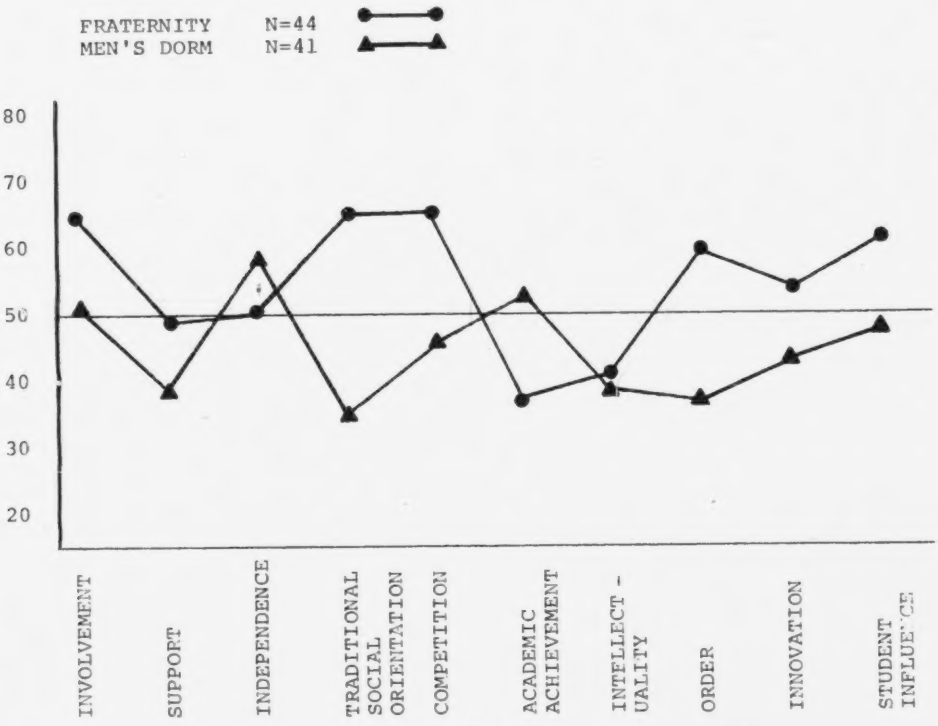

FIGURE 2

The differences between these groups are significant for all subscales excepting Intellectuality. While some differences such as Student Influence, Traditional Social Orientation and Innovation would be expected (e.g., Scott, 1964) it is surprising to note the much higher scores for the fraternity on the relationship variables. These results may be the joint effect of two variables. First, since fraternities select future members and initiate them, the degree of loyalty and group cohesion may be enhanced. Secondly, this selection process tends in increase the likelihood that members are similar in values, interests and attitudes which may lead to greater interpersonal attraction among members and thus further increase group cohesion and organizational loyality. A third variable may be the more "home-like" physical design of the fraternity which obtained greater face-to-face interaction and mutual influence.

Individual House Profiles

Individual profiles such as Figure 1 may be used for "feedback" to particular residences and can serve as the basis for discussions aimed at making specific changes in house atmosphere by the residents themselves. In Figure 1 the women's and coed houses may be compared as to their program development emphasis to indicate directions for possible change. The women's house in Figrue 1 had only a minimum of planned activities consisting mainly of a few parties and exchanges with neighboring men's dormitories during the academic year. Naturalistic observation of this house indicated it to be a quite friendly and open house, which nevertheless seemed to be rather conventional and dull, with for example, sexual behavior and psychedelic drug usage minimal.

On the other hand, the coed house in Figure 1 had organized an extensive program around a theme of international living and study of international politics. These emphases showed up most clearly in the high involvement score and very strong emphasis on the Intellectual Growth scales. Further, the pattern of scales in the System Maintenance and Change area shows a more deliberate attempt at change through meetings and refocusing of rules and methods of house government.

Discussion

The purpose of the research was to develop a social-psychological environment scale which would accurately describe and differentiate among the perceptions of residents in different student housing. The results from the URES demonstrate that the perceived social-psychological climate can be reliabley measured and thus aid in the systematic description and comparison of university residences. The psychometric and conceptual properties of the scale encourage its use in a number of research directions, some of which are summarized below.

Programatic Evaluation

The URES may be an effective tool in the evaluation of the impact on students of programatic and compositional innovations. For example many universities are currently instituting "living and learning" dormitories where much of the traditional class and seminar teaching is integrated into the residence with faculty members often living in the house. Other colleges and universities are establishing experimental living arrangements such as the coed housing presented above and bi-ethnic dormitories whereby 20-50% of the residence members of minority groups currently entering universities in significant numbers.

Change in Residence Climate

While programatic innovations may effect changes in the environment of a student residence, student initiated change may be more effective and provide a richer interpersonal learning experience for students. Such internally generated changes (via encounter groups, student projects, etc.) may be assessed by the URES and more interestingly the scale itself may be incorporated in a change program. There is some evidence (14) that people's knowledge of their own environment may be a powerful tool in enabling them to plan and implement changes along desired dimensions.

URES feedback may take a variety of forms. For example, a comparison showing residents their perceptions of an "ideal" house versus their perceptions of their actual living situation may be used as a basis to plan change strategies to reduce the real-ideal discrepancies. Further, a comparison of the perceptions of staff and students of their residence could make clear to each the areas of conflict, confusion and contradictory expectations of their shared environment and thus enhance the possibility of designing change measures.

Individual Impact

The effect of the immediate social environment on individual student development may also be approached using this instrument. For example, the manner in which a student perceives the social climate of his residence may influence his subjective mood states such as feelings of depression, alienation and isolation. Furthermore, a student's satisfaction with his residential environment may influence his feeling of satisfaction with himself and his overall college experience such that it influences his pursuit of relationships with others and the degree of involvement in intellectually and emotionally significant activities.

Person X Environment Interaction

The URES and other environmental assessment instruments such as WAS (Moos), the CCI (Stern), the ITA(Astin), etc., as examples of the measurement of situational and environmental regularities, also have implications for the assessment, prediction and modification of behavior. As trait theories of personality have been replaced by interactive theories, the necessity for the measurement of environmental settings in which behavior occurs has increased (15). Not only must situational variables be specified more exactly, but the boundaries and common elements of various environments must also de delimited.

Architectural and Design Influences

While large sums of money have been spent on the design and construction of student housing only sporadic attempts to assess the impact on their users have been made (16). For example, it may be that student residences which are designed in small clusters of rooms around a central courtyard are perceived as having more affiliation and involvement than dormitories arranged in straight line corridors.

Further by selecting dormitories from the very large number currently in operation on U.S. campuses, it would be possible to group samples of houses which were equated for age, sex, class, etc. of the residents while varying specific sets of design variables. For example, the number of one, two, and three person rooms may affect the quality of the perceived climate. Similary, traffic flow, the placement and number of lounge and kitchen areas may induce variations in perceptions.

While the above implies that the physical design is logically prior to and only lineally causal to perceived environment, in fact it seems reasonable that the process is more nearly interactive and mutually influential. That is, a dormitory which is perceived as having desirable psychosocial environment may be perceived as more esthetically pleasing than a house with an undesirable climate. It may also be that houses with "bad" design principles employed would help to induce a sense of cohesion and involvement among the residents and in the end allow it to become a more desirable unit in which to live. In turn, this "feedback loop" could mean that the house is then perceived as physically more pleasing although along dimensions different than those initially employed by the architect and even the residents themselves at first.

It may be possible that the psychological and behavioral consequences of variations in architectual planning can be approached using the URES as a measure of the psychosocial atmosphere.

NOTES

1. This research was supported in part by N.I.M.H. grants MN 16026, MN 10976, and MN 6315.

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COMMUNAL ARCHITECTURE AND SOCIAL STRUCTURE

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Introduction

For the past twenty months we have been engaged in the study of modern communal living arrangements, especially rural communes in northern California. The research has been sociological in nature and concerned primarily with child-raising practices. We are not trained in the gathering of architectural or design information, nor are we familiar with the major issues in these fields; our early formulations will require some indulgence from those who are. Some of the early results of our field work, however, prompted further consideration of commune "design" and the meanings assigned to spaces and structures.

We began, for example, with the presumption that communes were, as advertised, essentially isolated, self-contained and inward-looking settlements: among other things, knowable as places. Our journeys in and out of these settings indicated, however, that communards too are frequently on the move, or at least so in a large enough number of cases to make mobility an almost defining characteristic of communal life. (1) Partly as an adaptation to this fact and in part because of our attraction to "dramaturgical" models of social life now being developed by sociologists, we began to explore the use of theatrical metaphors in describing what we saw. Communes began to seem less like places and more like staging areas occupied by somewhat itinerant actors who form a troupe dedicated to the development and enactment of a somewhat specialized script. This formulation has its limits, but it has also sensitized us to what might be termed "visual appropriateness" in communal life; communes, perhaps but not necessarily more than other social gatherings, apparently need to be seen as such and are not adequately described as not-seen (except in print) "social structures."

In what follows we attempt a beginning formulation of the "natural history" of communal life, drawing our information primarily from rural communes that are not tightly organized around the principle of devotion to some religious or political creed. Even within the limited social world from which our data derives there is great variety in social practice; our model is, as a sociologist would say, "ideal-typical," concerned primarily with major tendencies. We will attempt to relate physical and social structures to each other and both to the "stages of development" of communal life.

Commune and Family

Communes typically begin in urban friendship groups, especially those that form in the middle-class, age-specific settings that university towns develop (most California communes probably begin in Berkeley), although more than friendship--mutual involvement in a political movement or marginal "underground" entrepreneurial activity--is often involved. The move to the country is a constitutional event; ties to the established world are at least in part severed, a geographical meaning is given to the distance that separates the communards from the "straight" world. The uncommitted are weeded out, and the very lack of skills in rural living, frequently present in a new commune, helps to insure a sense of departure, solidarity and equality. In the initial period especially, the emphasis is on communion: the intensified sharing of living quarters, affections, commitments, construction work and the rigors of the first winter. The creation or re-modeling of the central communal house may be the major communal activity: the work is shared (especially by the males), the resulting spatial arrangements de-emphasize privacy, and there is some attempt to employ unconventional structural design and material.

This central house is multipurpose and designed to satisfy the various needs of the communards. Still more important is the symbolic nature of this construction whether it be remodeling or creating. It serves to accentuate the ideology and gives place to that ideology. The communal house becomes a functional building only in the sense that it serves to reinforce the religious or spiritual nature of the communal endeavor. The activity generates the experience, thereby creating a structure that is sacred and adaptable at least during the first period of development.

"The disappearance of the living room wall was the first in a series of expressions

> individual and collective, of people coming out of their shells. Out of their shells in relation to place and to each other." (2)

The initial period is, in short, especially communal. It is a period of particular concern with ideological purification and "culture-creation." Much attention may be paid to the evils of the world from which one has departed and the beauties of the world into which one has entered. The crucial task is to establish or construct a scenario that provides a common or shared meaning to typical events. In present-day communes, for example, there is a great deal of attention given to indicating the concrete difference between a "natural" or "organic" lifestyle and the living patterns of an urban population. To be natural is to avoid contrived distinctions between work and play, males and females, adults and children. There are reasonably clear-cut ways to be natural in regard to food, childbearing, clothing, medicine, shelter, and to a lesser extent, sex. To be natural is to avoid traditional separations, contrivances and formalizations, and at the same time to be natural is to distinguish one's self clearly from those who are not: the "straight world." The importance of character rather than one's history accents the separation from the outside world. It does not matter where one comes from or what one has done in the past. There is an intentional refusal on the part of communards to comment at all about their past. In one sense it serves to reinforce the departure but also gives mandate to themselves that they are creating their own history.

In current communal settlements there is also some tendency to acquaint a natural lifestyle with an absence of binding communal authority, to maintain a rather libertarian ethos. This suits the style of those who are mobile, and it also gives a particularly "public" or open character to the meaning of "communal." Communes, particularly in the early stages, tend to proselytize rather than emphasize their isolation; they keep themselves open enough to visitors to be confronted continuously with "audiences" for whom, in turn, a relatively pristine version of communal life must be enacted: audiences, after all, enforce dedication to the script. The enactment takes place most prominently in the large communal house, and to a lesser extent in the garden and during important collective activities such as wood-gathering. The large communal house because of its flexibility and the open space within the structure, is extremely suited to the open quality of communal ideology at this time. It is interesting to note the placement of these activity areas. The definition of the spaces tends to follow the natural flow of the land, or what is taken to be the natural flow. There is relatively little protection from the access roads; the communal house, garden and work area are immediately visible to the outsider. What is created in effect is an open arrangement of land use which leaves the commune intentionally unprotected.

Because of the difficulty in the reorientation from a city life to a rural communal life much energy is expended with little productivity. During this period many projects are started but few are completed. The libertarian ethos and a dislike of authority creates conflicts directly related to "getting work done." The tendency is to reject any kind of time orientation--allowing the individual to do what he pleases when he wants.

The friction caused by this inability to perform work when it needs to be done is solved in part by the transition from communal to family. The scene grows slowly; the members begin to orient themselves to the rhythm of their new environment. And since the integration of work and play is considered to be important, the interaction among the communards in working situations gives way to the development of a practical rather than spiritual relationship with each other. That, in turn, allows for the almost natural transition to family as a necessary step.

Thus it is our surmise that in the early stages of commune-formation a relatively pure form of communal life and ideology is developed and performed; attention to purity is not to be taken for granted but is, rather, enforced, first by the original communards themselves and later by the periodic appearance of audiences. What is especially interesting and in a sense paradoxical is that the performing of a relatively ideal commune is not only distinguishable from a long-term commitment to dealing with the practical contingencies of the settlement but may, in fact, require actors whose commitments are superficial enough to allow belief in an idealized version of the communal scenario. As in some other social movements, the culture-bearers of the commune movement are often the least involved in it.

The development and enactment of the ideology takes place, as we have suggested, most prominently in the central communal house, and it is for this reason that committed communards frequently seek private residences, often at a considerable distance from the center. Among the most dedicated, particularly those whose skills have begun to have some considerable practical import, the more public idealized version of the commune becomes something of a burden, a roadblock to the development of more lasting, instrumental and mutually exploitive relationships that a relatively stable community both involves and requires.

Particularly in new communities that lack supportive institutions dedicated to protecting the community's particular style--institutions such as schools, medical clinics, stores, workplaces and public agencies--adaptive arrangements with the "outside world" that may do some violence to the commune's public identity have to be made. It is at this point that the transition from commune to a rather unorthodox "family" takes place. The notion of a family symbolizes an intensification of relationships, but it is the more private and the more practical character of these relationships that makes the family at least a partial solution to the problems raised by communal life. The family in this case involves an assemblage of individualized dwellings, but this may say less about the desire for traditional forms of privacy than about the difficulty of establishing a truly private commune. (3)

This shift of emphasis toward somewhat more individualized private dwellings may also be thought to embody territorial impulses or be seen as a kind of inexorable outcome of stratification processes in which those who are seen as contributing the most to the commune are ironically rewarded by not having to live in it. These developments need not be denied, but we would emphasize again the degree to which they help to redefine the character of the settlement as a whole, advancing at least the *presumption* of "familiarity" among members, the taken-for-granted nature of communion, and the social distance existing between members and "outsiders."

Dwellings as Design

Communal ideology involves most the rejection of *rationalized* social and physical structures--arrangements contrived without regard for those who live in or embody them. With the emergence of the family as the more dominant social force, the communal structures and activity areas give way to the creation of individual and more private dwellings. Whereas the critique of conventional society leans heavily on the distinction between natural and formal use or management of both time and space, communal architecture emphasizes the open and the adaptive. Insofar as possible behavior in relation to structures as well as social situations should be spontaneous--radically "occasional" spaces and people alike should be flexible and "open" to new experiences and in this sense continuously adapted to their environment. These dwellings, created partially because of a need to protect oneself from the constant "openess" that exists in the first stage of communal development, and to serve the more practical nature of social relationships, are highly individualistic: each structure seems to have a personality of its own. Whether the dwellings are symbolically in keeping with the communal image or artistic expression of individual builders each structure creates a more intimate experience between dweller and dwelling. There is relatively no definition of formality, but rather an emphasis on the informal. There exists a distinctive "organic" unity between dwelling, dweller and the surrounding terrain. The design of these homes involves an almost intentional attempt to create highly artistic statements in space, the enhancement of private and intimate experiences and the continuation of "family" relationships between communards.

These and similar guidelines are probably better suited to use as modes of imputing meaning to structures than as guides for actual construction. The function of these dwellings is to have some kind of meaning, not to necessarily be "functional" in the conventional sense. The VW bus converted into a dwelling and the owner-built, hand-hewn treehouse utilizing only "local" materials and only partially enclosed, both realize some or all of the appropriate values even if major conveniences are foregone. Consequently many of the structures lack the functionality of the normal house, but they have *meaning* directly related to the dweller because these structures are actually *extensions* of the self.

These types of adaptations and organic unities depend upon elementary considerations such as resource availability and the degree and nature of one's commitment to the communal setting. Quite often the resources needed to build houses is not abundantly available, nor are there sufficient finances to use to buy materials. Consequently the use of natural materials becomes a defining characteristic of communal architecture: the use of logs or of discarded glass and wood procured from nearby abandoned houses and lumber yards. The amount of materials bought is kept minimal and usually involves the purchase of such things as plastic tarp, roofing material or major wood beams. So the design of dwellings is limited by the availability of the materials which, of course, fits well with the intended organic nature of the structure. It should be noted that even if a builder can buy most of the materials needed, he still *intentionally* uses materials that seem organic in quality. Houses are built to fit the various pieces of glass and frames that have been procured. Many times because glass is a rare commodity, communards will travel many miles to bring back windows. The house is then built around these pieces, sometimes creating a strange but pleasing incongruity between entrances and doors, windows and walls.

During the first move away from the communal house temporary dwellings such as the lean-to, the plastic tent and the redwood bough house are constructed. These are typical types of housing generally associated with a poor or itinerant population. Because many of the activities still occur in the communal house, the temporary structure is quite appropriate. It indicates the need for some small private space, and secondly the nature of one's commitment. Usually the tenent of such places is still in the process of trying to understand his relation to the whole and he remains a highly mobile person, leaving the land for long periods at a time. Teepees and domes--antique and futuristic designs--involve slightly more affluence and "settlement" and gain much of their meaning as symbolic embodiments of the movement as a whole. Of course these kinds of structures, temporary and symbolic, eventually are torn down (with the exception of the dome) and replaced by the emergence of a more individualistic statement. In our view, structures of this type are not necessarily convenient and may be only minimally functional; what matters is that they depart substantially from "conventional" designs and are thus capable of being defined as structures that flow from and contribute to the lifestyle of the commune.

The individualized house consitutes another major category of dwelling which the values expressed are essentially those of the owner or builder--as opposed to the values embodied in a mobile lifestyle, intense communal living, or the "movement" as a whole. These dwellings characteristically begin to appear as the centrifugal tendencies noted above gain momentum, and may be frequently powerful architectural statements regarding the sanctity of personal interests. They also tend to make a stronger definition of one's commitment to the land and to the rural communal life. The dwellings are intended for use as a more private and intimate experience yet they conform well to the commune as an alternative institution. These individual homes support the social system of the commune: the intentional community. They allow for the easy interaction between members. A notable feature is the frequently "playful" use of space and structure--doors are usually located in unexpected places, bathtubs exposed to the natural environment, "sculptured" plumbing, windows of different sizes placed in unconventional ways, and outhouses designed as shrines--as contrasted with the sometimes aggressively functional appearance or interpretation given to structures such as teepees or domes.

The spaces are not fixed and extremely adaptive to may uses primarily because they are not formally defined but left "open." Since many functions such as eating, cooking and general socializing are still conducted in the communal houses, these dwellings are not large nor do they contain functional areas, for example a kitchen. Their intended use is to give protection and privacy to the individual in spiritual matters. There exists an intimate quality that is extremely uncomfortable when an "outsider" enters the dwelling. One is immediately impressed with the dramatic design of the interior. Usually the interior is not broken in any way but maintains complete unity with the structure. Meditation or study areas are predominant uses of the space place in such a way as to allow for an extremely intense spiritual experience through the use of skylights, lofts or small "shrine-like" furniture. (4) Almost all the artifacts that one normally surrounds oneself with are immediately visible to the visitor. There is a sense of intimacy with the dweller because there are no closets, bureaus, inside doors: few private areas within the dwelling. (5) This quality of intimacy more so than in conventional interiors, again accents the fact that these places are the extension of the self. The house becomes an object of art/love and is sacred and adaptive for the user.

The construction of these dwellings also defines the intentional ways that the builder seeks to personalize his environment. Most homes are built to fit well with the natural surroundings, in respect to natural lighting, best view, or most appropriate terrain. Since they are built to increase privacy, the structures are not visible to one another but close enough to walk from one to another. The individual or small group designs the home as they build, possibly starting with only a loosely defined image, adapting the structure to what they desire. The process is more an artistic creation than construction. In cases where the raising of the roof would better suit the natural light, the roof is raised; the adaptation of adding more glass or leaving a side without a wall is a decision that is arrived at organically. (6) What in effect is created is artistic housing designed poorly in respect to functionality, but a "hand made" house that asserts a strong definition of the owner: it is surely a "home." Living in art that one has created is intensely experiential and religious.

Needless to say, the unconventional character of some structures periodically produces colorful confrontations between communards and housing officials; the dwellings are often not "up to code." This gives practical meaning to the conflict between natural and formal designs, but it is also interesting to note that violations of the housing code may also come to be utilized as a practical indicator that one lives in a natural house.

Particularly aesthetic structures may involve considerable expense by or on behalf of a single individual or small group, but they may also symbolize the more general emergent values such as privacy and indicate both the rewards of dedication to the local setting and the concrete possibilities of breaking with convention. The "statement" made by these homes may, however, tend to displace even further the somewhat tenuous charisma of the communal idea, increasing the significance of private territories (beyond the privacy of the commune as a whole) and more personalized ambitions.

This is not, of course, necessarily a tragedy, for the communal idea need not itself be treated as sacred. Unconventionally organic and adaptive structures, both physical and social, may be forgiven for adapting themselves to existing conventions. Some communes, however, have given way to what one communard described as "hippie tract developments," with considerable attenuation of even mutually helpful relationships. The design problem here would seem to be that of exploring the possibilities for strengthening the privacy of the communal "family" without sacrificing the communal idea itself.

Our research indicates that there is an attempt on the part of communards to use structures as a way of imputing meaning to their life experience and more importantly to enhance the quality of that experience; be it spiritual or practical. The interplay between structures and people remains informal so that structure seems to support social interaction rather than define it. This kind of architecture symbolizes, and later achieves, adaptability. It indicates that one is alive in the present and not simply applying solutions arrived at elsewhere to present circumstances; it does not draw upon history for its sanctity. We are lead to believe that these places may serve to enhance instrumental or useful or mutually exploitive relations between members of the settlement. The attempt is to use structure and space to aid in the identification of the social system but to maintain a quality of informality and flexibility. The design problem seems to be achieving the sacred without destroying adaptability.

Notes

1) A substantial proportion of the communards we have interviewed come from families that experienced the suburbanization "movement" especially following the second world war; many current communes carry the movement a step further, drawing, in the process, on a legacy of hostility to cities that is widespread in the American population. That movement, in turn, is integral to the apparently accelerated mobility of the population in general and a consequent change in the relationship of persons to their settlements. There are communards whose grandparents were born and died in the same pre-established communities, whose parents were born in one established community and moved to one or more new cities or towns chosen or "consumed" for their utility, and for whom being born in one place and creating one's "settlement of orientation" forms something of a natural historical progression.

2) Diamond, Steve, What the Trees Said, 1971

3) "The difference between the commune and family has always been obvious: The commune is a place, an 'alternative institution,' which must of necessity give way to a more important and absolutely intrinsic social structure based on individual people and their relationships to each other. The family. Place must always be secondary in priority to the people, otherwise the magic stops."
What the Trees Said

4) "Diane's place had no closed spaces except for one which was a small loft with a curtain drawn in front. This was her meditation area. The roof of the loft was made of glass and the interior was simply decorated with various religious artifacts."
Field notes, Andrew Sun, 1971

5) Bachelard, Gaston, The Poetics of Space, 1964, Chapter 3

6) "Barry started with a four-walled shack. During the next four years he made adaptions as he needed. Now there are no walls at all. The shape described by the building resembles a parabolic arc majestically sweeping across the sky."
Field notes, Andrew Sun, 1971

TERRITORY AND STATUS - THE USES OF ENVIRONMENT WITHIN A COMMUNAL SOCIETY - SYNANON

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The Synanon Life Style

Interest in alternative life-styles to date has responded primarily to either a curiosity about what "they do", or has focused on the insufficiencies and inadequacies of the American way of life for which the alternative life-style is considered an antidote. It does not seem to have occurred to anyone in the design professions that adoption of an alternative life style might challenge and change many of the fundamental assumptions upon which architects and planners base their work - consciously or unconsciously.

If the omission is unfortunate, it is not surprising. The interconnection between the behavioural sciences and design is not only new but obscure to many, within and outside both fields. Both the language and the purpose of most inquiry in the field can discourage a serious professional in either area.

This paper is a report on the Synanon life-style as it relates to concepts of status and territory. What we will look at are the changes which occur in the use and understanding of status and territory within the Synanon community due to the Synanon life-style. These changes are very important for they run counter to many old as well as new ideas about the individual within his environment upon which much of our design work is currently based. If we can change our basic assumptions about status and territory because we accept an alternative life-style, then we can think of the possibility of restructuring the total environment from the position of that life-style. It is a possibility that has been largely unexplored because most of the "alternative" life-styles on the current American scene are very new and quite shaky in their solidity. They disintegrate and then disappear unable to structure a basic framework which can absorb and respond to change.

In contrast, Synanon is today the largest and most successful commune in the United States. By the end of 1972 its some 2,000 people with incredibly varied backgrounds will be resident in seven Synanon houses across the country. What began as a revolution in the treatment of the drug addict is today a full-fledged social movement. The most singular aspect of the Synanon community and its life-style is the centrality of the Synanon Game. No discussion of Synanon is possible without emphasizing the importance of the Game to all Synanon residents. It is the interaction between individuals, the Game and the community which develops the Synanon life-style.

The Synanon Game

The major part of this reporting about the Synanon environment comes from personal Game experience. For the Game is the constant source of data about the condition of the environment and the individual's position within it. Much has been written about the Synanon Game. It has been referred to as a "verbal street fight, an elementary forum, a microcosm, a small world whose dimensions are marked by multifarious, valid communication". Everyone who is a Synanon resident plays the Synanon Game. It is the constant demonstration of living in the Synanon community.

In its most simple description the Synanon Game amounts to nothing more than about 12 to 14 individuals sitting in a circle and talking to one another. They do so with honesty, without restriction and with no violence or the threat of violence. As with any game, experience and skill can count - but not always. The Game reflects how a person is seen by others as well as how he sees himself, individually and as part of the Synanon community.

Through the Synanon Game one gains his position in the community. It is not, however, nor can it be, a static position. It constantly changes in response to changes in the individual, changes in the community. The position which each person occupies in the Synanon community, as illuminated by the Game, is what gives real meaning to his status and his territory. As it is in essence a moral position which can only be demonstrated, as opposed to conceptualized or theorized, it is the community which recognizes its validity.

Before we get into how someone with a Synanon position, living the Synanon life-style views status and territory, it would be well to examine how narrow based and limiting are many of our current conceptions, the work of Ardrey and his contemporaries notwithstanding.

When F. Scott Fitzgerald says the "very rich are very different", one can almost fantasize that difference in terms of opulence and indulgence. Invariably life-style is viewed within an ethnic or economic frame. There are the rich and poor, black and white, Jew and W.A.S.P., etc., etc.

But they are all, for the most part, part of a nuclear family based society in which areas of personal responsibility, intimacy and accountability are severely limited to one's own blood relatives, wife and children. Only occasionally and even then with reluctance and awkwardness often assisted by alcohol or some other tongue-loosener, does one make public what is private or personal. Thus status in a nuclear family based world conjures up image, a look-good based upon exterior appearances and a position within the pecking order, corporate or geographic. It would appear that it is a matter of individual integrity or morality whether one gives into status needs. Those who drive dirty old V.W. buses feel innately superior to those driving Detroit's latest monsters. Faded levis are taken up as an expression of dropping out from a fashion-world dominated value system.

Status in Synanon

Status is a basic and fundamental consideration in design on an individual as well as on a broader environmental level. It is an obvious point and one need not go into endless explanation of how the demands of status exert an enormous influence on design today. What we are concerned with is what happens when we shift our focus from an area of private accountability to a public one such as one sees in Synanon, the Synanon Game and the Synanon Life-Style.

There is first, far less concern with an outward appearance of style only. Within Synanon there are considerable differences in the way in which individuals can and choose to live. Individual contribution and constancy count for a great deal. Synanon's founder, Charles E. Dederich, enjoys his own personal residence and Synanon Game room. But he dines primarily in a common dining room and rides a motorcycle dressed in overalls. In one sense "Chuck" does live better than anyone else. Yet he, too, lives in the community, playing the Synanon Game with a public accountability and record of his personal and corporate life that is unthinkable for a comparable corporate figure in a general society. Not only Synanon's founder, but its corporate leaders, the Board of Regents and its plant directors enjoy considerable status. It is not a status of exclusivity or the careful preservation of outward appearance. There is little desire to impress by extravagance in either size or elegance. The informality and even accessibility of Synanon's leaders is in sharp contrast to what one will encounter in a normal corporate planning. Often offices are part of a larger wild and wooly "buro-landschaft" type of living shed. If those with status do enjoy larger living quarters, they are within the community, not isolated from it. The exclusivity of the executive, with private, keyed washrooms and secretarial barriers is totally absent.

Status more often than not will demand aloofness, privacy and separateness. In Synanon this is not so, for status will mean a greater responsibility for involvement in one's community. A hierarchy of space which is public and private is not inappropriate to Synanon. But the difference relates to the character of what goes on in the spaces rather than any privilege or rank. "Character is the only rank" is often heard in Synanon as an expression that one's position of status in job, one's outward appearance, important as it might be, is secondary to the moral position obtained in the community. Even the term "environment" as phrased in Synanon, will refer more often to people resources rather than to a physical surround of buildings and geography. "Use your environment!" is heard very often in a Synanon Game, as a scream of frustration at one person's inability to accept or seek assistance and direction. Even this phrase emphasizes the secondary importance attached to outward appearance. There is considerable importance attached to personal appearance, to making things attractive. The daily lesson is that a new and better use can be put to what society discards in people, goods, services and buildings. Appearances are deceiving so much so that simplicity and direct expression become recognizable features of speech, dress and building. Large simple containers of space are what Synanon thrives on. That warehouses are so successfully adapted to Synanon houses is, in this light, no surprise.

Territory

It was Ardrey who popularized the concept of territory as a basic motivation which satisfies the need for security, stimulation and identity. He also reflected on "how few are the behavioural outlets which satisfy these needs. War has been one, territory is another and there is sometimes love". It is the other outlet, the social invention which Ardrey did not truly enlarge upon which Synanon illustrates so well.

The design professions have to date focused their energies exclusively on territory to almost the total exclusion of "the social invention" as a way of satisfying the human animal's need for security, stimulation and identity. But what does happen in a social setting such as Synanon where the community structure, and especially the Synanon Game, offers this satisfaction? The answer is obvious - territorial needs do not disappear but change and most important, territory need not be defended by physical force or aggresion. The Game in Synanon, because it makes everyone publicly accountable within the community, will diminish the hard physical boundaries of territory far more than might be thought possible. Diminish but not abolish for as Ardrey indicated territory is a basic instinct which has always motivated man, his ancestors and fellow creatures.

It is interesting to note the reaction of a "newcomer" to the Synanon society. Whether from a street background of crime and social delinquency or from a solid responsible citizen background, all who first move into Synanon are extremely resistant to really giving up any element of territory. This is true not so much out of defects of character such as whether one shoots dope or commits anti-social acts, but because the general society provides so little stimulation, identity and security. Each person takes time to learn for himself that he can obtain these needs in Synanon without using aggresive behaviour or drawing hard lines of no trespass around possessions or personal turf.

Synanon recognizes this and gives "newcomers" their own turf and peer group to provide a measure of physical security to allow the process of developing trust in the community its proper time. Some will require a familiarity of noise level and rock music and street speech for such assurance while others will cling to furniture, clothing or paintings to express their territorial demands. It is fascinating and often amusing to observe how each individual will establish his territorial prerogative more from fear of change than from a true need within Synanon. Territory is viewed exclusively as something personal. It is to this, and almost to this alone, that so much of our design and planning work addresses itself.

The incredible importance attached in western civilization, and especially in the United States, to the single family residence is but one result of this limited view of territory. The confusion of style with human needs another, for at no other period in history has man raced through so much and in so short a time. Frequent changes in clothing, mates, recreational needs show this very clearly.

In Synanon territory is primarily a setting for activities, not so much the personal demarcation of lines in the environment. This is true even on the most personal level of marriage where both husband and wife will each have a Synanon life-style arrangement of territory. Both man and woman must have their own place secure before they can share together. In observing how various couples design their territory in Synanon one is struck at how much it is the male, female differences which are expressed in settings and decor. This would seem to place primary importance on the man and woman roles which are to be played rather than overemphasize the personal idiosyncrasies present in each partner.

Within the larger community change makes the hard line establishment of territory very difficult. People within the Synanon community move a great deal. In the first 6 months of residence, the writer and his wife moved to new living quarters three times. The term "rotation" is used and it is most apt. It is part of a giant oscillation, designed to loosen the individual from a petty and almost trivial dependency on one apartment, one office, one environment. If indeed it is the total Synanon community from which one obtains his position, then it is more often an "accident" of geography, or time-space, which establishes personal territory.

From Synanon's founder and where he lives and does his business to the newest arrival in Synanon there is ample evidence that although "place" and territory are vital, it is a changing affair from one day to the other. Any effort to design an environment exclusively in terms of one person's needs of that moment is doomed to fail in Synanon. The large residence designed for Chuck Dederich at Synanon's Tomales Bay property is today a delightful residence for over 20 young children. The learning experience over what truly makes one's territory in Synanon is more comic than painful. Frequent moves disabuse one of "heavy" personal effects. The familiar saying that he who travels best, travels light is appropriate to an appreciation of territory in Synanon. Within general society, within the design professions especially, it is almost heresy to entertain such a thought.

The "heaviest" design and planning efforts might be those which attend to the most details, which overvalue the need to satisfy individual and specialized requirements. A series of closed and unrelated systems then develop - all part of a fragmented society. A separate territory for each system - it is wrong for it simply does not work and it is a far cry from what Ardrey and Lorenz would have us learn from their studies.

Synanon illustrates what can happen in an open and integrated society as opposed to a closed and fragmented one. It is the life-style itself with its moral position in the community which gives the line and edge to one's territory, however personal, however small or large. In Synanon once the community understands, accepts and supports an activity, those who do that work can demand and obtain the tools, space and facility to do that work. It is the essential community support which makes for an absence of territorial boundaries, which eliminates aggression as an element of community. Without such support and approval, we will continue to do what we now do so well - make our territorial concern a reflection of our worst fears and alienation.

The Old and the New - the Real Ecology

What is posed here is hardly new or unheard of. Viollet-le-Duc described how the change in social patterns gave a change in the structure of medieval churches and town halls. If it has not always been true, it is certainly so today. Real architecture in our day can only be developed by those who like to construct new social patterns.

But no one should have any illusions about the difficulty of doing so. Even the assertion of an alternative life-style throws our society into panic and rage. Synanon's experience is not one which would encourage the weak or faint-hearted. The desire for community, the desire for engagement and the desire for dependence are deeply and uniquely frustrated in America today. It is this essential frustration and rage which must be resolved before we can structure a physical environment that can satisfy man's emotional and material needs and stimulate his spiritual growth.

Synanon is that kind of communal society which, to date, seems to be able for some people to satisfy basic status and territorial needs without resorting to highly individualistic or stylistic expression. What the new concern for ecology seems to be saying to all of us is that we had better let up on some of the unreasonable demands we are putting on the society, or our environment, before it is too late.

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CONCEPTS AND METHODS FOR STUDYING ENVIRONMENTS IN USE

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Two theoretical problems have prompted this small pilot study. They are in quite separate realms, nicely polarized in scale as well: theories of urban and regional growth, and behavior setting theory as developed by Roger Barker. After discussing each, I will give the particulars of my study which, in its turn, is more conceptual and methodological than substantively conclusive.

Large-Scale Systems Theory and the Human Consequences of Environments

Complex and interdependent systems of action and reaction, composed of people, land, transport, and employment are, it can be agreed generally, the subject matter of city and regional planning. Just as complex and sophisticated theoretical approaches -- often expressed in mathematical models of descriptive or explanatory kinds -- are being worked out to understand these processes in terms of interactions among the observable properties of cost, time, distance, and other quantitative terms. Appropriately enough the economists, geographers, and planners are in charge of these explorations into systems, and if their work identifies this tiny subfield of ours -- something to do with environment-and-behavior, or the psychology of space, orpeople in space, or "what people want" -- it is only because they are well enough educated to know there is something -- whatever it is -- that their theories might use. They may even speak directly of "preferences" or "cultural values." Failing that, at least "the demand side" sums up the vagaries of human action.

Public policy at all levels of government is influenced if not by the models' outputs, then by the theorists themselves, their hypotheses and assumptions. All of their work underlies the basic issue of allocating and distributing public goods: the public's infrastructure expenditures -- whether followed or preceded by private investment -- are really the topics treated by urban and regional growth theories. I mean to suggest that our subfield locate itself exactly inside of these macrosystem issues. Ours are not residual questions after all other explanatory devices have been exhausted -- intra-urban migration patterns, birth rates, accessibility costs -- but rather our questions are the feedback mechanisms always posted within any macrosystem. Uniquely we are in the business of evaluating directly the human consequences of the processes of growth and change, to assist in the secondary evaluation of alternative policies and plans.

This theoretical connection has to be insisted upon, for without it, macro growth theories exclude evaluation when it is by definition integral to anything called a system. In regional transportation studies, for example, our kinds of questions should be valued (and funded) equally to those of bi-modal splits which, after all, do reduce to what people do and why. It might be argued that the reductionism is understood as a given of these elaborate theoretical constructs, and it is exactly my point that the givenness amounts to inattention. Britton Harris says,

> "When we examine in detail the problem of designing the future city, we find that in many respects this becomes the problem of designing a setting for all society. Insofar as this difficulty must be faced, it suggests that economic models of equilibrium and optimization are not enough, and, indeed, that the objective function and the means by which it is maximized must cover a wider range of social forces and social values....
>
> "Policy planning...may be devoted to changing the rules of the game and thus the structure of the world to which analysis and theory apply. Mortgage insurance, urban renewal, and the interstate highway program may be taken as examples of the type of structural change greatly influencing the development of urban areas. Prior to their invention, they were not in general a part of the world which the analyst examined. In the future, we may expect that to deal with urgent urban problems many new devices of similar magnitude will have to be invented. Frequently, perceptive analysis may actually originate these suggestions. In general, even though basic qualities of human behavior and economic reality will persist, we may expect that some such changes will so drastically alter the structure of urban affairs that they may even call for new theories and certainly for new models." (1)

On theoretical grounds we must gain a means -- now missing -- of understanding the human costs and benefits of these allocation choices. These are not ordinary free-market choices, where the producer gets feedback via consumer demand levels. Because public decisions about the built environment are both very expensive and long-lived the responsibility is, on the one hand, to avoid wasting scarce resources, and on the other, to avoid charging people with high adaptive costs -- social, psychological, monetary -- for incongruent environments. For people who can afford the adaptive costs the fixed environment represents little problem. Money can give mastery over otherwise captive environments; so can occupational mobility. But when monetary and personal resources are limited -- and when the scale of infrastructure captures everyone in a region -- and the consumer rejects the supply, the rejection is of necessity transformed into adaptations of various intensities and importance. What are they? What are their social and biological costs and benefits?

The decisiveness of public policy is, then, surmountable, when it is surmountable, by those populations with the adaptive capacities their income and other resources provide. The expense of owning two cars in suburbs without public transport is a cost borne in order to master that environmental lack; families without the income for two cars adapt in other ways. These are also the populations for whom the public sector is making the most unsurmountable decisions -- whether in the house construction criteria of the FHA or the cost limitations of various housing programs. And so one question always basic to ask prior to the actual work of evaluating alternatives for changing the environment, is: who has control within the environment itself? Is it at the captive end of the continuum, or does it permit the genuine consideration of options? Satisfaction, preference, and even health, I am suggesting, are in the first place a function of the level of self-control over environments: we have called this "consumer choice" which the planner is obligated professionally to maximize, but I prefer the more emphatic term, in order to reveal the not-so-subtle difference between being the captive of, say, high-rise public housing with too few elevators, and one with enough.

Following on this, my work gets consciously into questions of some magnitude: by confining ourselves to a few stereotypes of physical arrangements and landscape, are we closing off options for behaviors themselves that may contribute more effectively than those we now maximize for human well-being? How do our allocations of resources to create interior spaces of various kinds relate, in the cost-benefit terms of behavioral adaptations, to human well-being? The particular questions others choose, as exemplified in this collection of papers, also illustrate the great importance of asserting the intimate connection between our microlevel concerns with human response and theoretical issues of only seemingly greater magnitude.

Behavior Setting Theory and Adaptation Mechanisms

The one certainty about the contributions of environmental designers and planners is that they add new physical objects to our world. We all share in perceiving and in taking meanings from them, and largely for that reason the research emphasis has grown out of perception and cognition. The stimulus-response model has been useful as well, not only to designers but to psychologists working in the arena of the built environment.

That model has been attractive on still another score, it seems to me, in that people are viewed as more or less passive recipients of a stimulus managed by the designer. If only the designer (or psychologist) hits upon the right stimulus, they may think, then people will respond in a predictable way -- hence a logical interest in visual cues, symbols, semiotics, nonverbal communication as tools for directing behavior. These more subtle influences on behavior are replacing previous ideas about space and buildings as determinants of social interactions, now pretty much discredited. When taken to its limits, stimulus-response becomes the model of the behavioral psychologists who can modify and change human behavior by controlling its consquences, reinforcing through aversive and rewarding stimuli only behavior that is desired. Certainly many kinds of environments could be more purposefully designed to achieve the outcome for which they have been established -- as in reformatories that reform, mental hospitals that cure, schools in which students learn. Much about their physical design can reinforce the goals of the people administering the programs in such institutions.

I have been working with a different model in order to learn about another set of human processes, which views ordinary people as actively pursuing objectives they are aware of. The distinction is perhaps parallel to the difference between people's responses to the visual and auditory stimuli of art or music and their capacity to participate in the artist's intuitions as an active partner in the aesthetic experience. People carry out various behaviors in fulfillment of their objectives, and they utilize the physical and human environment to do so effectively. As they carry out these behaviors, they expend energies -- physical and psychic -- in adapting themselves to existing conditions or in trying to change the conditions. The environment that is incongruent to a purpose carries a high adaptive cost. This relationship between environment and behavior is now being looked at most carefully at both extremities of the life cycle in work with the young and the old, where limited capacities are sufficiently apparent that extensions of those capacities via various types of resources are readily visible and measurable.

The work of ecological psychology has concentrated on, and indeed largely developed, a model for studying behavior in the round, as it were, looking for lawful relationships between molar behavior and environment. The connection Barker delineates between inhabitants and milieu -- that is, the behavior setting -- consists of three features: perception by inhabitants of goals within settings and of paths to them; the achievement of goals; and satisfaction of need via consummatory behavior. (2) "The behavior setting is the total, extra-individual pattern of behavior and milieu." (3)

In this formulation we begin, then, with human purposes and intentions lying within consciousness, which leads to distinctive methods of observation, record-taking, and analysis. In animal ethology per se we are usually learning inductively about purpose from the details of behavior. When we have a human situation in which people can tell their purposes, we are led to ask as Barker does, how it is "maintained with its routes and goals intact." He outlines two mechanisms: in a behavior setting, deviation-countering actions are set in motion in order that the "program" of the behavior setting can be carried out. These actions consist of two parts: "sensing by inhabitants, or other components of the behavior setting, of conditions that prevent carrying out the program," and, second, "actions to counteract the interfering (deviant, inadequate) conditions." (4) The second mechanism of vetoing actions are identical, except that instead of countering what is deviant, it is eliminated.

"Vetoing circuits are involved when an inaccurate employee is not corrected but fired; and when a broken shelf is not repaired but discarded." (5)

To explain the existence of these circuits, Barker postulates the intervening mechanism of the TOTE unit (Test-Operate-Test-Exit, originated by Miller, Galanter, and Pribram). (6) It is essentially a feedback loop between cognition and action. Barker uses the TOTE concept as a "behavior setting sensing mechanism...which senses and transmits information about settings." He uses additionally what he terms an "executive mechanism...which tests information about settings against inhabitants' criteria of behavior setting adequacy." Barker thus not only ascribes overt purposes to behavior setting inhabitants in the first place, but he also attributes to them a "standard" for the optimal workings of the setting on behalf of their purposes. The person senses and reacts so that the level of activity engaged in brings the setting to the level of his "criteria of an adequate setting in view of his goal aspirations and program plans" and it is "proportional to the sensed state of the setting and the inhabitants' standard."

Barker defines human and mechanical (material objects) channels along which both the deviation-countering and vetoing mechanisms can occur. (7) Each of these in turn terminates in either inhabitants or milieu. Barker adds that a judgment is made each time by the executive mechanism whether to veto or counter the deviation, such that its task is "to balance the effort-cost of countering a deviant component against the effort-cost of maintaining the adequacy of the setting." (8) In this, I find the rudiments of a cost-benefit approach to human adaptations in the environment.

The executive mechanism, in Barker's terms, makes these judgments; in my terms, this is the operation performed by the ego in order to maintain or strive toward a sense of competence in the encounter with the milieu of a behavior setting. These operations are the adaptations people are making continuously as they go about their purposes. To the extent that they realize their objectives, they are effective, self-satisfied, and competent.

"What this leads to is measuring the stress and strain of adaptation in the physical environment in terms of ego strength, just as physiological stress is measured with heart rate and blood pressure....The essential mediating term belonging in a theory of human nature for environmental design is in the striving of people for equilibrium in the various realms of their personal and social life, toward that which maintains and extends their sense of competence and self-esteem." (9)

The question forming the basis of my pilot study is, then, when people tell about being in and of their physical environment to carry out their purposes, what are the adaptation mechanisms they use to maintain their competence? For the moment I am not studying behavior settings per se, but looking instead to categorize only the molar behaviors brought into play in the maintenance of various programs within a single physical environment -- in this instance, a dwelling. The cognitive map of the situation is postulated to have already been drawn, and the individual is in the state of taking action -- or in the psychologist's terms, translating afferent patterns into efferent patterns, which in turn are responding to both external conditions and interior evaluations, as compressed in the TOTE mechanism.

"According to behavior setting theory, the ecological environment of human molar behavior and its inhabitants are not independent; rather, the environment is a set of homeostatically governed eco-behavioral entities consisting of nonhuman components, human components, and control circuits that modify the components in predictable ways to maintain the environmental entities in their characteristic states. These states are defined by schedules, or programs, or intraentity occurrences. If one control circuit does not produce the programmed occurrence from an inhabitant or component, other circuits are activated...." (10)

Eventually, I suggest, it should be possible to do a behavior setting inventory of various types of dwellings and neighborhoods that will yield, for example, a "behavior mechanism profile" (11) and a "pressure profile" correlated to scores of ego strength or levels of self-esteem and competence. I would like to see such profiles made of various types of behaviors as they are distributed within a variety of milieux, following out a typology like the one suggested by Lawton for the "sublevels of individual organization," which organizes behavior between simple and complex, and then in terms of categories (not hierarchies necessarily): life maintenance, functional health, perception-cognition, physical self-maintenance, instrumental self-maintenance, effectance, and social role. (12)

The implications are immense: we would find out about behaviors for which current milieux provide inadequate human and nonhuman resources; we would be able to evaluate milieux in terms of effort-cost and benefit; we would be able to rank behaviors in a tradeoff framework for given groups; and we would be able to evaluate comparatively the level of change in a group by finding out just how much behavior is concerned, in Barker's words, "with creating new milieu arrangements to support new standing patterns of behavior, or altering old milieu features to conform to changes in old patterns of behavior."

These are explanations of the interaction between "environment and behavior" at far remove from those achievable with what I call "summing" concepts or variables, where the generalizations sought leave out of account precisely those processes needed to explain the consequences -- concepts such as role and status, or "activity systems" and "time budgets" in neighborhood and city, or the census-based ecology, so-called, of small area analysis.

The Pilot Study

The primary purpose of this pilot study was to demonstrate the terrain, as it were, of the way people use and talk about their residential environment when left to their own ideas and categories, and to find out whether "deviation-countering (and vetoing) mechanisms" are accessible for study. The eventual goal is to discover productive questions to ask in customary survey research, because the questionnaire is likely to continue to be our most efficient and economic instrument for large-scale data collection. But I chose to approach this goal only by first using the methods of "naturalistic" research in order to discover what such questions might be. To this end, I gave still cameras to four families, treating them more as informants in the anthropological sense and as participant observers than as respondents in an interview situation. After the slides were developed (more study details below), members of the family discussed the reasons why the pictures were taken in a viewing session with the investigator. The picture-viewing sessions were held in two stages, and each time I handed over the developed slides, asked the informant to show them in any sequence wanted, and gave over control of the slide showing. The sessions were tape recorded, consisting both of free comments on the reasons why the slides were taken and of responses to my questions and probes. The tape recording was transcribed, and a content analysis is reported below -- but no reliability checks of my evaluation and interpretations of the data have been made.

In this, I have tried to maintain a "naturalistic" research perspective to the degree possible -- that is, a low level of manipulation of antecedent conditions (they took pictures whenever they chose, over a period of weeks) and without imposing units of analysis (in the first stage they chose all the pictures to take; the second phase was of places and situations I specified). (13) I also achieved a high level of unobtrusiveness during the data collection stage by being absent; in order not to be thought of as a "typical" survey-maker, I did not ask any basic demographic questions.

The slides were intended, then, only as the stimuli for the verbal material, and in my analysis of those data I have tried to perceive them as natural phenomena in and of themselves: that what people are telling about their everyday life in their residential environment can be seen as data to be observed, interpreted, and analyzed on its own terms, in much the same way as Barker deals with the "stream of behavior." As Willems puts it, "If the research question is what kinds of behavioral achievements persons... make when left to their own resources, the methods used should involve at least low manipulation and perhaps low imposition of units...." (14)

The "everyday behavioral achievements" of interest to me are, however, ordered by several concepts. The concept of behavioral expectations leads to a view of the physical and human environment as a resource for carrying out those purposes a person expects to be able to accomplish in his environment; these expectations vary as do the age, sex, socioeconomic status, ethnicity of the individual. The fulfillment or disappointment of his expectations shapes his opinions of or attitudes about the environment, as an objective reality, and about himself. The concept of the individual's sense of competence, identity, and self-esteem as enhanced, diminished, or supported by the environmental resources available or unavailable to him is united with behavioral expectations in the unit of analysis I term the behavior circuit: that for the everyday actions a person engages in to accomplish his purposes -- carry out his behavioral expectations -- there is a more or less regularized and identifiable series of acts pointed toward an outcome. Within the circuit there is the opportunity for greater and less expenditure of time, energy, and self-satisfaction relative to the environmental and human resources available for carrying out the circuit (e.g., doing the dishes, vacuuming the house, having friends for dinner).

The Study Design Four families, each with several children, were selected in order to study households making maximum use of their housing environment, subjecting it to the greatest demands for livability. The families are living in housing that is ostensibly of appropriate size, so that no obvious disparity exists between their demands and the environment's adequacy to meet them. The housing is that built fairly recently under various private, middle-income programs; in this way, the kind of housing most likely to be built in future, under present programs and standards, is involved. Two families live in a middle-income suburb, and the other two are living in the central city. In the suburb the houses are attached-row, in two stories; in the central city the units are within garden apartments of three stories.

Each family took color slide photos of daily activities within their dwelling, in two distinct stages. In the first, very few instructions were given of what to photograph ("the first 40 pictures should reflect your family's own choices"). The person to take the pictures was never specified either, and purposely avoided. Families received payment for their participation and were given the cameras to keep, but no family refused to participate even before knowing of the rewards. No one had any trouble with the mechanics of taking pictures (Kodak Instamatics), and three of the four women had never operated a camera before. Many pictures were taken by children; some were of people dressed in their best. From this tiny group, I can say that there is a fair chance that the method of eliciting data can be relied on as extremely productive. The suburban households each took about 80 pictures; one central city family took about 40 and the other about 20.

Lack of space prevents reproducing the instructions in full. In the first stage, the central theme was:

> "The only 'direction' to follow in taking the first 40 pictures is that they should be of ways in which you live in your house. That means the beds will be unmade sometimes, dirty dishes in the sink, children's toys spread around, the newspapers all over the floor, people barefoot, hairuncombed, and so on. You are not being asked to take a picture of anything you consider to be private, and you will have the right to remove from the study any picture you choose."

In the second stage, a specific number and kind of picture were requested, only after the first stage was completely over and the discussion had been recorded. Because these instructions do try to identify behavior settings and behavior circuits in operational terms, they are presented at greater length.

"A. The first type of picture is the place where something goes on. Please take pictures of these places: where the family meals are eaten; where meals with company or extra guests are eaten; bathroom; sleeping place of each family member; place where guests are put up; playing space for children of each age, alone and with others; studying place of children; reading place of adults; telephone place; writing place; laundry drying places for big and small washes; storage places; kitchen trash and garbage; any other places in the house you want to include.

"B. The second type of picture is of the steps you take in doing things. The pictures should show at least three things: the beginning of the activity (for example, getting ready to do it by taking things out of storage), doing it (bending over and scrubbing, or typing), and finishing (putting things away). [Pictures were requested of activities such as: child getting off to school; big housecleaning; ironing; cleaning up kitchen after dinner; father's hobby or chores around the house; family activities on a rainy Saturday. These followed the typology of behavior circuits previously defined (15), that is, routines, collaborations, and events.]"

The Families The suburban households each occupied an attached row house of two stories and usable basement in Park Forest, about 35 miles from downtown Chicago. The tenure was a combination of cooperative and rental, where a small down payment assured tax deductions and a tenants' council made management decisions. The Holton family had two bedrooms; the Ronald's had three originally, but had added a bedroom (windowless) in the basement. The Holtons lived in two bedrooms with three children, all under 5. The Ronalds lived in the four bedroom unit with six children (five boys, 15, 13, 11, and 2, and one girl, 9). Both men work in the Loop, commuting Monday through Friday, spending about three hours each day travelling. Mr. Ronald works in an optical supply firm and has another job nearby evenings and weekends; Mr. Holton is an IBM repairman.

The central city households were the first tenants about a year before the study of new garden apartments, the result of nonprofit sponsorship by a black community organization. The Brackens are the grandparents of four children of Mrs. Brackens' daughter, and they have complete care of the children -- two boys 7 and 9, and two girls 11 and 15. Both Brackens are retired and in their 60's. Mrs. Ames has five children and is divorced; the family lives in the same development in a three-bedroom apartment all on one floor; the Brackens are in a two-story, three-bedroom unit. The three Ames girls are 7, 9, and 15 and the two boys are 5 and 8. Mrs. Ames is a letter carrier.

Contents of the Verbal Material The discussions of the slides ranged from three-quarters of an hour to more than two hours. On the first visit I met with the woman of the household during the week when children were in school and husband at work or not home; on the second visit I came when the husband was home and the children were around. I asked the husband also to discuss the slides on this second visit, and encouraged the older children to talk as well. Any future work should certainly include children as informants.

The analysis of the verbal material can be but merely suggestive of directions for future work. It covers a great deal of territory, and is perhaps only journalism now, without testing for observer correlations or realiability. But I am able to suggestthat participation in the everyday residential environment has meanings to people that are accessible to systematic analysis with the concepts of competence, behavioral expectations, and adaptation mechanisms. That is, data ordered by these concepts are accessible: people can readily discuss what they do. No attributions need be made through statistical correlations, no questions to "get at" attitudes need to be devised. The reasons why people make any adaptation are contained within their explanation of it. For example, Mrs. Ronald described how she locks the back door, opening onto the kitchen, in order to force her six children to use the front door, when she is engrossed in cooking and does not want to be disturbed.

I consistently asked several questions that were precipitated by the informants' explanations of the slides:

What kinds of things do you -- and children and husband -- begin to do but don't finish?

What are the kinds of interruptions you have?

What kinds of things do you like to do that you find you don't do?

What changes have you made to your house? What have you "invented" to make it work better for you? What do you want to own next?

In this I elicited statements about the adaptations people make in themselves and in their environment, requiring the payment of costs in money and time. Similarly, when people complain about defects in their surroundings and have not done anything about them, the reasons for their inaction are also interesting. Mrs. Ronald complained about a wall separating the dining area from the kitchen; the dining area was constantly used. The separation meant to her getting up from the dining table and moving into the kitchen in order to bring food or utensils needed as the meal progressed, missing out on conversations. I asked her in every indirect way I could think of to discuss with me the possibility of taking down the wall -- had she ever looked into it? -- and I failed to get her to bring it up herself. I finally asked about it directly, and she replied that such a change had never been thought of because the tenure arrangement would necessitate the double expense of taking down the wall and then, upon leaving the unit, putting it back in as it was.

Other questions asked were:

What did you expect to be able to do in this house when you moved in? Has it met your expectations?

When you have more income, what changes in your living would you make first, second, third?

Are you raising your family very differently from the way you were raised?

What does being crowded mean to you? Inside the house? in the neighborhood? downtown?

How do you manage family members' needs for privacy and for company?

Although I asked these questions, it should be remembered that the original direction of each discussion was established by the slides. Following is the content analysis of the verbal material, organized into statements expressing one complete idea, numbering about 150 in all for the four families. The statements were coded according to theme.

1) Adaptation mechanisms

A. Change or control self
B. Change or control physical environment (adding objects, changing location)
C. Change or control others in human environment
D. If change, veto behavior
E. If change, reprimand behavior
F. Not doing: "no place to"
G. Not doing: no resources for doing (lack of furniture or space)
H. Unfinished, interrupted
I. No or very minor change wanted in environment or self
J. Making do -- no change possible or a difficulty to be coped with
K. Explicit tradeoff expressed for a negative adaptation

The first five categories represent Barker's deviation-countering and vetoing mechanisms; and the last six are related to my concepts of competence, expectation, and adaptation.

Category B was mentioned the most often, with a wide range of evidence presented for the ways in which people Changed or Controlled their Physical Environment. Although Mrs. Ronald had not added so much as a hook to her kitchen, using it exactly as it came, the same family had built the fourth bedroom for the two oldest boys. Mrs. Bracken remarked, "I've made everything here work for me."

Changing or Controlling Self was mentioned second most often, probably because the women of the household did most of the talking. For Mrs. Ronald to accomplish an evening meal she felt suitable for eight people, she said she had to cook some of it ahead of time in the morning, because her small kitchen made it too hard to get everything pulled together at once. She did not make that kind of meal, therefore, everyday of the week; she felt free to do other things some mornings.

The categories of Not Doing, whether No Place To or No Resources For received a high number of mentions. For the Bracken children it was not having enough space in their bedrooms for having friends in and for dancing. For Tom Holton it was not having a garage to pull his car into for tinkering with. For Mrs. Ronald it was not baking as often or as much as she liked because her work space was too skimpy for the large bowls and pans she needed to work with.

Under those behaviors that were Interrupted or Unfinished I coded the mentions of the necessity for always having to put things out of the way, even if they were unfinished, because single spaces had to serve many purposes. In the Holton household, the 5-year-old's various constructions -- cars and tracks, tinkertoy structures -- had to be picked up off the living room floor and put away, even if he were in the middle of a project. In the Bracken's apartment the boys' bikes had to be stored under the stairs inside the unit, along with many other objects. Much effort had to go into taking them out of doors and putting them back; no street-level storage facilities had been built.

In all four households the bedrooms were not useful for activities much beyond sitting still and watching TV, sleeping, and dressing. As a result, the living-dining areas took most of family and individual doings, and one activity would quickly supplant another -- with the result that the children's painting project would have to be interrupted or put away in order for the ironing to begin. Both women in Park Forest liked to sew, and always did it at night when there would be an uninterrupted stretch of time at the dining table, their only place for work using that much equipment and space.

The category Making Do grew out of the informants' own expressions. Mrs. Ames had several negative comments about the size and design of her kitchen: she left the house at 6:30 a.m., six days a week, delivered mail all day, and during supper preparations welcomed help from her 15-year old. But there was barely room for the two people, let alone the little boys who always wanted to be in the same place after not seeing their mother all day. She also commented that once the bedrooms had furniture in them "there was no room to do anything else." Even so, she explictly accepted these difficulties of adapting to her apartment, and was glad of a new and clean place.

Both the men in Park Forest mentioned their explicit decision to move so far from their work and their dislike of the three hours a day in travel. But at the same time, they spoke of the savings in housing costs and thegood environment for their children and wives.

"Satisfaction" found expression in mentions within the category No or Very Minor Changes wanted in Self or Environment -- all of these mentions came from the Park Forest families and none from the central city households.

2) Content specifying different kinds of behaviors

Simple-to-complex behaviors within each category, after Lawton (12):

A. Life maintenance (prophylactic; breathing
B. Functional health (athletic;immobile)
C. Perception-cognition (creativity; sensation)
D. Physical self-maintenance (grooming; locomotion)
E. Instrumental self-maintenance (paid work; housekeeping)
F. Effectance (innovation-exploration; changing positions of receptors)
G. Social role (leadership; interpersonal contacts)

I found no expressed content on categories A and B, and only one theme relating to C. The next most frequently spoken of was E. The most frequently mentioned was Effectance, doubtless a result of my probes, but interesting nonetheless that spontaneous mentions of Perception-Creativity were infrequent. See the discussion of Visual Qualities.

3) Content using currently popular concepts

A. Privacy
B. Crowding
C. Territory
D. Sense of community
E. Freedom of choice
F. Role - Identity
G. Good neighboring
H. Conflict, tension
I. Bad neighborhood

In my traverse of the verbal material, as well as the photographic evidence, I searched out commentary couched in the several popular ways currently in use when discussing "environment" and its meaning -- popular for design professionals, social scientists, and urban journalists, for example. I looked for both actual use of the words themselves and of meanings I could perceive or attribute.

Conflict and Tension in the household and the immediate environs was mentioned the most, but still only 4 times. (In Park Forest it was connected to the parking area in the courtyard, where cars astride marked lines or parking by visitors gave rise to hostile exchanges or tensions. In the inner city, children's play outdoors was restricted by aggressive teenagers and adults in the vicinity.) Privacy and Crowding were each mentioned twice. Freedom of Choice and Role-Identity (of self and others) was not mentioned at all.

4) Visual and Physical qualities of environment

- A. Attractive
- B. Unattractive
- C. Too small, narrow
- D. Large enough

The first two categories were those I looked for in the material, to see what mention was made of the appearance of the environment, in whatever way. Neither Attractive nor Unattractive -- or synonyms -- was in the material per se. Mrs. Holton remarked that she loved the low windows in her dining space overlooking the parking area and back entrances of the court because her small children stood looking out for hours and were entertained. In the same way, Mrs. Bracken remarked that she just loved her kitchen because all her equipment fit and she was thrilled to find it painted yellow -- her favorite color. "How did they know?" she asked in wonder.

Too Small, Narrow were mentioned twice as often by the central city households as by the Park Forest families. Bedrooms and bathrooms were mentioned for the difficulty of fitting people's activities into them. Mrs. Bracken spoke of having to get rid of much furniture and other posessions in order to fit into her apartment, with the same number of family members as previously. Large Enough was mentioned once, in Park Forest: Tom Holton had an elaborate electronics workbench in the basement, spending every spare moment at it, and before moving to Park Forest four years previously, it had occupied the dining area of their apartment.

5) Purchases wanted next

- A. Furniture
- B. Radio-TV
- C. Paint
- D. Bigger house
- E. Camper (vehicle)

There were 15 mentions of any purchases at all, stimulated by my direct question, and 9 of them specified furniture of various kinds. The Ronalds wanted a large desk for the adults, Mrs. Bracken and Mrs. Holton wanted additional and new living room furniture. The Ronalds wanted a bigger house and the Holtons wanted a camper. Mrs. Ames wanted Paint to clean up her apartment hall walls. Mrs. Holton wanted a stero-FM radio and new TV. Getting answers to this question took prodding -- neither the women nor the men were immediately ready with answers.

6) Functional qualities evaluated

- A. Poor performance, low quality
- B. Previous house larger
- C. Room that would fit needs: alternative described

In combing the verbal material I found relatively few "summings-up" about their housing; there were many more individualized, specific, and qualified statements about particulars, doubtless because of my interest in how they lived and in hearing about the details of the ways in which they did things.

I found 12 mentions in Park Forest and 1 in the central city of Rooms That Would Fit Needs. Mrs. Holton complained about the locations available for her washer and dryer -- two flights of stairs away from the bedrooms, which were the source of her washes. And then the electric outlets were at the far end of the basement, away from the stairs. She knew just how she would like it to be arranged. Mrs. Ronald objected to the back porch and described how she thought it should be arranged better, for storage and weather protection. Mrs. Ames described a kitchen large enough to put a table for working and eating.

Conclusions

The examples in the preceding analysis have been intended only to clarify the category of analysis -- certainly not to be read as "findings" or "insights" about housing livability, which has not been the subject of this pilot.

The model of purposeful and conscious behavior toward a goal -- the basis of the theory of behavior settings and the concept of competence -- is enough borne out in this brief exploration to merit further inquiry. The ordinary person has the capacity to describe alternatives that would help him carry out his purposes: he *is* an active participant, with exepriences and ideas about how he would adapt his environment or himself. We have learned that people "prefer" what they already know, and have found that a fairly dead end both for design and research. But we have not been asking what people need for doing things that are important to them.

In the lack of self-consciousness about Role-Identity -- if that is indeed the case -- people may be telling us that various summing concepts could be tying together variables whose connections may be more abstract than actual. For example, each of the families lived in units whose exterior and interior design and layout were repeated in their immediate vicinity. No mention was made of a connection between these stereotypes and the person's "sense of identity" and no expression of dissatisfaction on this score was made. The pictures taken in order to make any comments about the look of the environment were of the indoors, to show sun coming into a bedroom or to show party decorations. Mrs. Ronald took a picture of their lawn because they enjoyed sitting out on it. The newness of the inner city housing was a positive aspect for the two black families, previously residents of old housing, even though I find it monotonous looking. What is at stake in concepts like role is that they form a unit of analysis for the social scientist to handle. The behavior circuit, I suggest, is a more revealing unit in research into the human use of the environment, in that it may juxtapose variables belonging together naturally. (16)

The nexus of adaptive behaviors under the categories Unfinished or Interrupted, Not Doing, No Resources or Place for Doing seems to me the most important for future research. In the situations reported by these informants, one consequence of "small" spaces is that people -- the children especially -- are unable to work or play cumulatively at the same activity, thus seeing the consequences of what they had begun to do. Behavior circuits are not completed. What is the relationship between behaviors of these kinds and self-esteem and the sense of competence -- at any time of life? What kinds of behavior circuits are completed? Questions like these characterize human stress as a function of environmental conditions in more concrete terms than we are capable of now. Furthermore, we may learn about things we can ameliorate effectively.

And we may discover what contributes as well to curiosity and exploration. What adaptive strategies are inventive and resourceful? Mrs. Holton likes to iron, and she likes to talk to someone at the same time. She found a neighbor who felt the same way, and in the warm months they each set up their ironing boards outdoors, on the sidewalk in the back court. Mrs. Ronald had a picture taken of her "jumping on the garbage", as she put it: garbage and rubbish collections are infrequent and so limited that every cubic inch is used. When neighbors go away on trips, their trash cans are filled with what other families have longed to get rid of.

If there are demonstrable consequences of "small" space -- in my terms, housing that is not an adequate resource for the behaviors people have that bring them self-satisfaction and a sense of competence -- then we should find it out quickly, before we keep on building it. Of single-family housing 800-899 square feet (the second smallest category recorded), about 17 percent more has been built in the last 20 years than in the previous 20. But whereas 60 to 70 percent of older, existing houses at that size have two bedrooms, now 80 to 85 percent of new houses at that size are being built with three bedrooms. The occupancy is meant to increase by at least one person, possibly two. Because of a 10 percent increase in housing since 1960 built with four bedrooms, the claim can be made -- as the Census Bureau does -- that "bigger" housing is being built. (17)

By beginning with behaviors and the various levels of importance diverse groups in society attach to them, we can evaluate the degree to which environmental resources (indoor, outdoor, city and regional) charge adaptive costs and yield benefits. Per capita or quantitative standards for open space, lot sizes, or floor area, for example, have been handy for professionals with decisions to make, but they have suggested no theoretical connections to their human consequences. The concepts and methods barely outlined here are intended to help bring these connections about.

The work reported here was conducted while I was a Fellow of the Adlai Stevenson Institute of International Affairs.

Notes

(1) Britton Harris, "The City of the Future: The Problem of Optimal Design," in Larry S. Bourne, editor, Internal Structure of the City (New York: Oxford University Press, 1971), pp. 520-521.

(2) Roger G. Barker, Ecological Psychology (Stanford: Stanford University Press, 1968), p. 178.

(3) Ibid., p. 34.

(4) Ibid., p. 169.

(5) Ibid., p. 171.

(6) George A. Miller, Eugene Galanter, Karl H. Pribram, Plans and the Structure of Behavior (New York: Holt, Rinehart and Winston, Inc. 1960), pp. 26-7.

(7) Barker, Ecological Psychology, p. 176.

(8) Ibid., p. 177.

(9) Constance Perin, With Man in Mind (Cambridge: The MIT Press, 1970), pp. 46 and 122.

(10) Roger Barker, Ecological Psychology, p. 186.

(11) Ibid., pp. 118-122.

(12) M. Powell Lawton, "Assessment, Integration, and Environments for Older People," The Gerontologist, Vol. 10, No. 1 (Spring 1970), p. 41.

(13) Edwin P. Willems, "Planning a Rationale for Naturalistic Research," in Edwin P. Willems and Harold L. Raush, editors, Naturalistic

Viewpoints in Psychological Research (New York: Holt, Rinehart and Winston, 1969) pp. 46-7.

(14) Ibid., p. 51.

(15) Perin, With Man in Mind, pp. 97-101.

(16) Ibid., pp. 77-86.

(17) Constance Perin, "The Size of Housing, Its Occupancy, Cost, and Price," Unpublished, October 1971, 25 pp. Data are from FHA Tables 36, 37, 41a, 41b, 45a, 45b, 53a, 53b, US Department of Housing and Urban Development, Statistical Summary, 1[illegible]9.

FAMILIES IN PUBLIC HOUSING: A STUDY OF THREE LOCALITIES IN ROCKFORD, ILLINOIS

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Abstract

The architects, developers and administrators of public housing are in need of immediate practical information upon which they might base their design and management decisions. This need can best be fulfilled by the continuing accumulation of data from numerous studies, and by the development of information gathering mechanisms that can be used easily by such producers of public housing. The study described in this paper is addressed to both of these approaches. An evaluation of three public housing developments in Rockford, Illinois, it documents the designers' intentions, the attitudes of the residents and their observed activities on two of the sites. From the analysis of this information are drawn suggestions relating to design and management which apply specifically to the housing in Rockford and also have implications for other housing situations. It is our intention to describe briefly the purposes and execution of the overall study and to concentrate on some of the methods used for information collection and analysis. The full study is documented elsewhere as a research report of the Committee on Housing Research and Development, University of Illinois at Urbana-Champaign (2).

Background

Public housing in the United States has not had a history of success in responding to the specific needs of low income families. Many of the failures would appear to be both in the design and the management of public housing. The developers of new housing are presently limited in the criteria by which they can evaluate their decisions. They tend to rely heavily on the available cost, construction and space standards and on their own experience. This might suffice if they were building housing for their own use, but the cultural differences which usually exist between them and the actual users of the housing make these sources unsatisfactory. No body of information exists which can interpret for them the social, psychological and physical needs of the future residents.

Similarly, those involved with the actual design of public housing, the architects, designers and formulators of HUD design guidelines, are culturally removed from the users and generally lack even the practical experience that a project manager might have. Feedback mechanisms by which previous examples might be evaluated are rarely used and those that are, rarely yield the kind of behavioral and attitudinal information that is necessary.

The social functioning of the physical design of public housing cannot be assessed without consideration of the management system under which it operated. Certain aspects of management are usually considered in the design of new housing. However, many others are not, and project managers rarely have any input in the design process. Most public housing is treated as a standard rental situation and the management is not geared to handle the particular problems of residents who require an unusual amount of public services. The management approach would seem to be at least as important to residents' satisfaction as the physical design of the housing.

Objectives

It is unlikely that there will be any radical change in the approach to supplying housing for low-income families in the near future. Our intention, therefore, is not to look for alternatives to public housing but to improve the present system. This can be accomplished by developing a new set of criteria upon which decisions can be based. What is needed is an evaluation mechanism that will provide developers, designers and managers with useful empirical information based on behavioral and attitudinal data. The decision makers should be made aware of the way in which social-psychological factors can influence design and management decisions.

The study being reported in this paper attempts to develop an evaluation mechanism which could be used by housing authorities or other similar groups with the aid of suitable technical expertise. The intention also is to develop cumulative knowledge in the area of low-income residential design. The approach is similar to that used by Clare Cooper in her studies of Easter Hill Village, St. Francis Square and Geneva Towers. It is also related to work done by the Housing Research and Development Group, Department of the Environment in Great Britain and the Environmental Research and Development Foundation in Kansas City (3).

Specifically, the study is an evaluation of the design of two public housing projects in Rockford, Illinois. Particular aspects of a third housing development on sites scattered throughout the city were also investigated. The approach taken was to determine and relate:

a. designers' expectations of residents' use of the house and site,

b. residents' attitudes and expectations regarding the house, layout and locality,

c. residents' actual activity and behavior inside and around the house and layout, and

d. physical characteristics of the environment.

The study includes an examination of the suitability of the interior design and materials, a seasonal comparison of outdoor resident activities, a comparison of the use of the two housing sites, and comparison of the attitudes of a sample of female residents at each of the sites.

We also examined the Rockford Housing Authority's current program of single-family and duplex units for homeownership on scattered sites. The study examines some of the problems and benefits of living in this type of housing for low-income families and some of the attitudes toward participation in an ownership program. Where suitable, comparisons are drawn between the projects and the scattered sites units.

Locations Studied

The multi-family project at Orton Keyes Courts was chosen for examination because preliminary studies had been undertaken there in the summer of 1970 and a fine working relationship had been established with the residents and managers (4).

The project consists of 175 one and two story, rental dwelling units ranging in size from one to six bedrooms. With the exception of 28 units along the northern periphery of the site, dwellings are arranged in clusters around partially paved courts. This site was previously occupied by army barracks which had been remodeled into public housing.

The site is located in a generally mixed industrial and residential area, approximately two and half miles south of the central business district. The first phase of building was completed early in 1969, the final phase early in 1970.

The project at Fairgrounds Valley was chosen for its many similarities to Orton Keyes Courts so that a comparison could be made of some of the factors in site location, site layout and residents' use of the houses and sites. The two projects have somewhat similar densities (13.7 dwellings/acre at Fairgrounds Valley and 9.2 dwellings/acre at Orton Keyes Courts), size (210 dwellings at Fairgrounds Valley and 175 dwellings at Orton Keyes Courts), and building types (predominantly two-story row houses in both projects).

The 210 two-story rental dwelling units range in size from two to six bedrooms The project is intersected by a creek and an infrequently used single-track railroad. The dwellings are grouped in rows of up to 5 units around partially paved courts or parking areas.

The site is approximately one mile west of the central business district in a predominantly single-family residential area. It is on the fringe of commercial properties on major routes to the downtown. The first phase was completed in November 1968 and the final phase in August 1969.

Rockford was the first housing authority in the country to implement a Turnkey III program of scattered-site single-family and duplex units. The 226 units scattered in suburban residential localities were developed for ownership by public housing residents. The seven basic one and two story house types were built on sites varying from single vacant lots in older parts of the city to recently developed lots in the newer suburbs. The first units were completed in February 1970.

Data Collection Methods

Data for this study were gathered from four sources: (a) interviews with the architects and personnel involved in housing management, (b) personal interviews with residents, (c) Rockford Housing Authority records, and (d) field observations.

To isolate certain key issues and to provide a basis for comparison, the architects of the three housing developments were interviewed prior to any field work. The interviews attempted to ascertain the way in which they expected their designs to be used. The discussion was supplemented by reference to the architects' drawings. Cases where expectations were confirmed or not confirmed are noted throughout the report.

Informal discussions were held with people involved in the daily functioning of the projects. These people included the managers and some assistant managers of Orton Keyes Courts, Fairgrounds Valley and the Scattered Site units, the presidents of the Women's Clubs at Orton Keyes and Fairgrounds, and the recreation organizers in the projects. Information gathered from these discussions was used to isolate important issues to be studied.

A major portion of the research involved interviewing residents at each of the three locations: Orton Keyes Courts, Fairgrounds Valley and the Scattered Sites. The survey was conducted by trained interviewers during the weekend of May 22-23, 1971.

Several days before interviewing was to take place, potential respondents received a letter from the Committee asking them to expect someone to call during the weekend, explaining the purpose of the study, and offering them $2.00 for their participation. The letters were addressed to the principal female at each address selected, either the wife or the female head of the household.

Ninety-seven housewives were interviewed:

Numbers of Interviews

	OK	FV	SS
Families interviewed	33	32	32
Reasons for no interview:			
Unit vacant	2	3	--
Family never home	--	2	1
Refusal	2	1	1
Sampling error	--	--	1
Total sample	37	38	35

The interviews covered points about the use of the houses and their adequacy, the location of the houses and the projects, and a variety of issues concerning the site, family activities, the Housing Authority and home ownership.

Basic demographic information on families to be included in the personal interview survey was obtained from the files of the Rockford Housing Authority. Such data was invaluable for relating certain family characteristics to survey information.

Field Observations

The observation techniques are described in more detail here not because we feel they are more important than other techniques, but because they form a useful introduction to the whole study and we felt they might be an appropriate concentration for this paper.

Observations were undertaken to form a general picture of activities in the projects and to provide some indicators of attitudes of the residents. The techniques fall under two general headings, (a) observation and notation of activities: those which provided information on the distribution, intensity and types of activities on the site throughout the day and, (b) observation and notation of physical characteristics of the residential settings: particularly those which described elements of the physical environment which had been affected by people in the course of the daily functioning of the projects. This included documentation of the position and quantity of parked automobiles, of equipment and toys left outside the houses overnight and documentation of the changes that residents had made to the spaces adjacent to their houses and of the general condition of landscaping and site work.

Observation and Notation of Activities

Observations were made during both weekdays and weekends in winter, spring and summer conditions at Orton Keyes Courts and in the summer at Fairgrounds Valley. Pairs of observers walked through the sites on regular routes which enabled every portion of the site to be viewed once on each circuit. They repeated these observations every hour throughout the day, averaging 10 to 11 circuits per day in the summer and 7 to 8 circuits in the winter.

On a plan of the housing site, the observers recorded the position of persons involved in a stationary activity or the path of a moving person for approximately ten seconds after initial observation. Each activity was labelled with a number which referred to descriptive information on a second sheet.

On this sheet were recorded the observation reference number, the number of people involved, their sex, race, estimated age, and notes describing the activity and any equipment or toys being used. The time and weather conditions were also recorded at the beginning of each circuit. The circuits took between 20 and 45 minutes to complete, depending on the site and amount of activity.

The notations were analyzed both graphically and mathematically. By superimposing notations made on the plans used during the various circuits, the locations most used by certain age groups or for certain activities could be determined for various days or times of day. Figure 1 shows the compilation of all the activities observed on three days at Orton Keyes Courts.

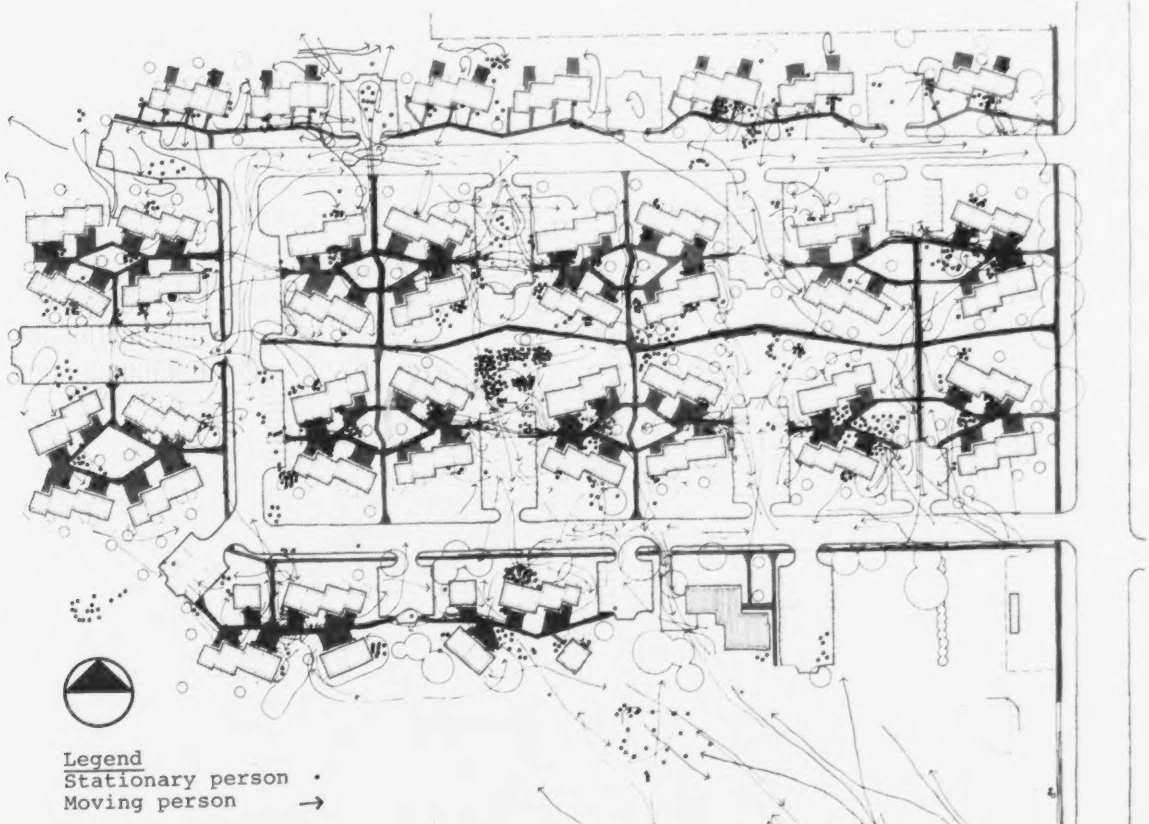


Figure 1. Distribution of Activity, Orton Keyes Courts

Location			Orton Keyes Court		Fairgrounds Valley	
			Weekend	Weekday	Weekend	Weekday
In-court	Grassed	General	8%	6%	6%	7%
	Paved	Pedestrian paths	10	10	7	8
		Drying areas	21	18	34	29
		Toddlers' play areas	3	6	not applicable	
Out-court	Grassed	Public area	6	6	5	7
		Play area	6	8	not applicable	
		Adjacent to house	9	11	8	10
	Paved	Road	6	3	1	1
		Parking court	7	9	17	15
		Pedestrian paths	5	7	11	14
		Patios	10	7	7	7
Community center environs			1	1	1	1
Sabrooke playground			8	8	not applicable	
Railroad bridge			not applicable		1	1
Creek bank			not applicable		2	2
		Total Observations	100% n=1748	100% n=1744	100% n=1870	100% n=1528

Observations documented in similar weather conditions and over similar time periods: May 8-11 and July 18-19.

Figure 2. Distribution of People on Site from Observation (All Activities)

Notations were categorized by location (a series of detailed land surface descriptions similar to those listed in Figure 2), and by description of the people involved (sex, race and approximate age). The activities observed were categorized as follows:

Bicycling	Standing	Alone
		With others
	Moving	Alone
		With others
Sitting	Apparent purpose	Alone
		With others
	No apparent purpose	Alone
		With others
Playing	Active	Alone
		With others
	Passive	Alone
		With others
Standing	Apparent purpose	Alone
		With others
	No apparent purpose	Alone
		With others
Walking	Apparent purpose	Alone
		With others
	No apparent purpose	Alone
		With others

These were further defined by the residents use of furniture or equipment. For example, we documented whether a person walking to or from a grocery store or laundromat was carrying a package.

These categories were then related using matrices. The most useful relationships were made between activity and location, activity and time, description of people and location, and description of people and activity. Figure 2 shows the distribution of people on the two sites during different days in the week.

From these matrices we obtained the percentages of certain age groups engaged in specific activities on individual days and during different periods of the day. In addition, the matrices yielded information on the use of different types of activity as well as the density of use. Seasonal differences in levels and types of activity were also collated.

Observation and Notation of Physical Characteristics

The following elements of the physical environment were also noted on plans of the sites: (a) the condition of landscaping (b) the resident personalization of land adjacent to their houses (c) equipment and toys left outside the houses overnight (d) parked automabiles. (a) and (b) were recorded once during the summer studies, (c) was recorded on several mornings of the observations before activity began in earnest for the day, and (d) was recorded on every activity observation circuit.

Relating Observation and Interview Data

In addition to the independent analysis of observation and interview data, an attempt was made to relate one to the other. This was particularly valuable in comparing the expectations of the architects about the use of the housing with the use as reported by the residents in the interviews and the observed use of the site. Residents' comments about site activity and use were also compared with observed data, as were those attitudes of the residents that might be influenced by particular types of site activity. For example, the location of children's outdoor play activity as related to the expressed satisfaction with the size of the house.

Some other observation data were coded with the resident interview data for computer analysis. For example, data on resident personalization of property and the position of their house on the layout were related to information concerning their interest in maintaining the yard or starting a garden and satisfaction with their house and its position on the layout.

Valuable information was also obtained by relating plans of the resident's house type with answers to questions about the house and how it was used. Where a resident's complaints focused on certain points in a particular house type (e.g. the size of the living room), we were able to refer to the plans and the interview data and check some of the possible causes of the dissatisfaction.

Findings from Comparison of Design Intentions and Actual Use

The interview with the architect of Orton Keyes Courts revealed a set of design assumptions about the use of the site. Apparently, he wanted to avoid the "barracks" appearance of the original housing project located on the site. In the previous housing project the kitchen doors faced onto the street, with garbage storage and personal belongings visible to the passerby. To avoid this, the architect placed the dwellings around partially enclosed service courts with the kitchen doors opening onto them. This aesthetic rationale for design also generated a positive basis for social interaction, with the kitchen side (indoors and outdoors) becoming the focal point for inter-familial interaction and intra-familial activities. The net result was a positive contribution to the social aspect of the project.

The designer's expectations of how people would use the dwelling unit were often contrary to their actual use. Though the kitchen door was meant to be the "back door" of the unit, it was used much more as an entranceway than the main door on the living room side in all dwelling court configurations.

This finding was also true at Fairgrounds Valley, which has a similar design concept. Ethnicity might also play a part in such behavior: our findings show that black families tended to use their kitchens more than white families as an area for social interaction.

Similarly, the use of the circulation routes through the site was misjudged. The central sidewalk (refer to plan, Figure 1), designed to collect the pedestrian traffic through the site toward the main road and points beyond, is rarely used except by cyclists. Residents walk parallel to it through the courts or at right angles to it through the central green space and take shortcuts through the playground to the south.

Assumptions like these result from lack of information on how people behave in specific situations. Another example was seen in the design of toddler's play areas at Orton Keyes Courts (Fairgrounds Valley has a fenced paved area intended for such use; the equipment has since been destroyed). These play areas were observed to be utilized less than the drying courts. In fact, the dwelling courts contained more activity than the institutionalized play areas on site. The same was true for Fairgrounds Valley, where the dwelling units were arranged around parking/service courts; the parking courts proved to be very popular play areas among the children. This finding reveals the need for further research into recreational play areas, their location and use. Such traditional accommodation for recreational activities may not be a crucial ingredient in such a project, and expenditure on such facilities should be carefully evaluated.

Some General Findings and Suggestions From Study

The major purpose of the study was to develop practical suggestions for the improvement of design and management methods for the Housing Authority. These suggestions were categorized under General, Ownership program, Design and

Construction Site and External Design, Landscaping-External Maintenance, Cars and Parking, Opportunity for Children's Play,and House Types. A few of the findings and suggestions are listed here to illustrate the nature and scope of the recommendations.

Ownership Program - Scattered Sites

The ownership program of scattered single-family and duplex units should be continued. Residents in the scattered sites commented very favorably about ownership. In addition to comments about financial benefits, their expressed personal satisfaction and freedom should be considered great achievements.

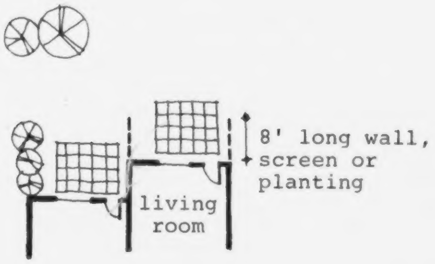
Design and Construction

Kitchens should be able to seat all family members at one time conveniently. This arrangement would effectively provide two general living rooms on the ground floor where differing activities could take place without disturbing each other.

The second bedroom in family houses should be designed to accommodate study and children's play activities in addition to sleeping; in houses without basements all children's bedrooms should be equipped for these purposes.

Site and External Design Recommendations

Paved patios should be provided of sufficient size for the the family to sit or cook and eat, out on the living room side of the house. Dimensions of 12' by 15' seem to be a minimum. The patios should be afforded at least partial visual screening, especially at Fairgrounds Valley, and should face some attractive outlook.



Although the distances to the stores and laundromats for Orton Keyes residents are almost the same as for Fairgrounds Valley, the choice of stores, the walk across the open playground and the lack of well-located footpaths appears to make them more inconvenient at Orton Keyes.

Pedestrian routes on the site should be direct, well surfaced and afford some protection from winter weather conditions. If not designed in this way, residents will make their own direct paths, as across the playground at Orton Keyes. Routes should not pass close to or disturb the living room sides of the houses.

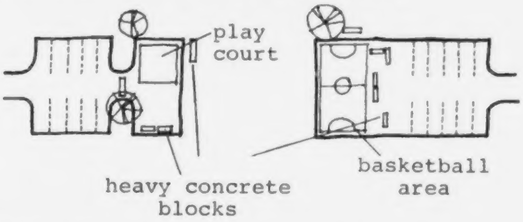
Landscaping - External Maintenance

Landscaping and site work should be completed prior to occupancy of the houses. This was unfortunately not the case at Orton Keyes or Fairgrounds Valley. Subsequent changes in landscaping or site work should not be left in unfinished condition for long periods.

Boundaries of maintenance responsibility should be made clear to the residents, preferably by some physical boundaries. Although not encouraged at present, residents should be able to construct fences around their yards if they wish.

Cars and Parking

Less than half the project families own automobiles, and the parking provision of 1.5 car spaces per family is never used to more than half its capacity. Parking provision need never initially be more than double the expected car-ownership level. If city ordinances will not allow less (or more) than their current requirements, parking areas might be planned but used for some other function until they are needed.



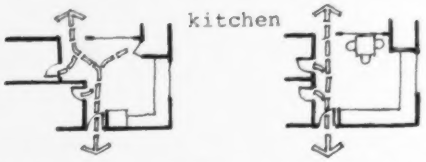
While the distances caused few complaints, many residents thought it important to be able to see their cars, which the location of parking areas now makes difficult.

House Types

Certain house types were causing a greater number of complaints. Below is a list of the types mentioned most frequently with a summary of the inadequacies.

Orton Keyes - 2 bedrooms, 2 story.
Residents' Comments:
Location and size of kitchen storage are inadequate.

Suggestions: The irregular shape of the plan and the position of doors have made taking meals difficult and reduced the amount of space for storage. Kitchens should be organized so that circulation does not interfere with work or eating spaces and so that sufficient counter space and storage can be provided in convenient positions.

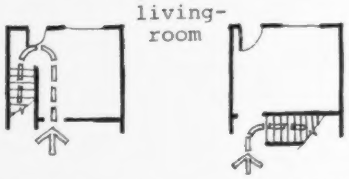


existing arrangement showing circulation

arrangement with circulation by-passing eating and work spaces

Fairgrounds Valley - 2 bedrooms, 2 story.
Residents' Comments:
Needs a larger living room (the stairs enter the living room, taking space for circulation).

Suggestions: Stairs to upper floors should be situated off common circulation areas so that they can be reached from the most commonly used entrance without disturbing other household activities.



existing plan showing circulation to reach stairs

plan showing revised position of stairs

Usefulness of Observation Techniques and Suggestions

Although the study is limited in scope, the flexibility and potential of the methodology are worth elaborating upon. First of all, the observation technique does not involve the participation of a large body of researchers. It can be carried out without interfering with the daily activities of the residents and with a minimum of research equipment. As such, it offers an economical approach to data collection. Secondly, the four approaches to data collection can be carried out simultaneously with proper co-ordination and planning. Aside from the interview schedule, there is no inherent ordering to the different studies utilized. Finally, the four sources of information act as checks on each other and as guides for further research in this area of investigation.

The observation technique utilized in the study proved to be a simple method of gathering a significant amount of information. One of the secondary objectives of the study was to help the housing authority (or any similar group) develop its own evaluation and feedback mechanism; as such, this method of data collection appears simple enough for use by such groups with some professional assistance to obtain feedback on the physical environment and the use of the site. It seems feasible to train project residents to document this type of information, and form part of the evaluation mechanism of the housing authority.

For the purpose of research, however, these techniques could be refined further for convenience. A grid could be applied to the site and coded for the computer in order to analyse the information in a more efficient manner. Alternately, the physical elements of the site could be categorized to varying levels of specificity and coded for computer analysis.

The basic premise of the study was that by examining the values and assumptions of the producers of public housing (architects and sponsors) and comparing them to those of the users of this housing, we might achieve a more precise evaluation of the effectiveness of both the programs and design by finding those areas of greatest concern, and particularly those areas where the different value systems conflict, it was hoped that the issues requiring resolution could be identified. The limited findings of this study suggest that research techniques used in data collection and analysis are applicable to the more general problem of research into the area of low-income housing production (public and private). To date very little research has been carried out which attempts to measure the success of residential design in catering to the needs of the inhabitants of public housing. The need, however, is not for just more research, but for a continuity of approaches which will allow the data from many such studies to be compared and the results to be cumulative. The study described here outlines a methodological approach which might provide a framework for such continuity.

Footnotes

(1) Research staff for study:

D. G. Saile	Principal Investigator Architecture
J. R. Anderson	Research Assistant Urban Planning
R. Borooah	Research Associate Architecture
A. Ray	Research Associate Social Psychology
K. Rohlfing	Research Assistant Architecture
C. Simpson	Research Assistant Sociology
A. E. Sutton	Research Assistant Architecture
M. G. Williams	Research Associate Architecture

The work was undertaken with the technical and financial assistance and cooperation of staff, managers and administrators of the Rockford Housing Authority, Rockford, Illinois.

(2) Committee on Housing Research and Development, University of Illinois at Urbana-Champaign, 1972

(3) See:
Cooper, Clare, Some Social Implications of House and Site Plan Design at Easter Hill Village, A Case Study, University of California at Berkeley, Center for Planning and Development Research, 1965

Cooper, Clare, Resident Attitudes Towards the Environment at St. Francis Square, San Francisco: A Summary of the Initial Findings, University of California at Berkeley, Center for Planning and Development Research, 1970

Ministry of Housing and Local Government, Family Houses at West Ham: An Account of the Project Appraisal, London, Her Majesty's Stationary Office, 1969

Srivastava, R. K., and L. R. Good, St. Margaret's Park Public Housing Project: An Environmental and Behavioral Profile, Kansas City, The Environmental Research Foundation, 1969

(4) Activities and Attitudes of Public Housing Residents: Rockford, Illinois, Committee on Housing Research and Development, University of Illinois at Urbana-Champaign, 1971

RESIDENTIAL LIVABILITY: A STUDY OF USER ATTITUDES TOWARDS THEIR RESIDENTIAL ENVIRONMENT

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Introduction

It can be said that this decade is characterized by two important facts: first a large number of people are living in urban environments, especially dwellings which were not designed or built for them, second, a significant proportion of the urban environment has been undergoing slow and consistent deterioration. Planners and social scientists in the recent years have increasingly come to recognize these facts as foci of many social problems and frustrations. Through state and federal programs, as well as private industry, various types of housing tenure will become available in the next decade. For effective solutions for housing people, it is essential that the type of housing and tenure reflect their needs and values.

Increased housing stock must be considered in view of the heterogeneity of the user population, as well as in consideration of the interpersonal commitments in the neighborhood. Relocation, resulting from renewal, especially for the poor, may result in social discontinuity since the dwelling and the neighborhood are inextricably linked.(1) This view of the residential area as a home and the significance of local people suggests the importance of the knowledge of users' needs as a vital ingredient in planning decisions.(2)

Existing studies(3) suggest that perceptions of good and friendly neighbors are related to satisfaction with the neighborhood. Social relationships are influenced and explained by people's homogeniety with respect to a variety of characteristics. Studies of social life have shown that people tend to choose friends on the basis of similarities in backgrounds such as age and socio-economic level, values such as those with respect to privacy and child rearing and interests such as leisure activity preferences.

Objectives and Methodology

The present study then is essentially concerned with identifying and understanding the dwelling and neighborhood dimensions with which families living in predominantly low-income sections feel satisfied or dissatisfied and the dimensions they consider important in their dwelling and neighborhoods. This objective would ultimately provide design criteria to be employed for a diverse population by establishing relationships between people's attitudes toward and evaluations of the environment (dependent variables) and demographic and socio-psychological factors (independent variables).

Description of the Population

A questionnaire was administered in the town of Asheboro, North Carolina, with a population of 20,000. The town is a rapidly growing, small manufacturing area with substantial need for new and improved housing. The town was subdivided into areas with a high concentration of black and white low-income families from which the sample was drawn.

Of the 145 persons selected for the sample, 89 were black and 56 were white. Distribution of the two groups by income showed that while a little over half (51.7%) of the black respondents indicated their annual incomes at less than $3,000, the corresponding proportion for whites was 30.3%. Since the sample was drawn from among low income families, it was not surprising that only 34.0% of whites and 16.9% blacks reported annual incomes in excess of $7,000.

Distribution of the respondents by age indicates that the sample did not include many young people (26.2% of the respondents were less than 35 years of age, 44.9% were above 51 years of age). Consistent with this is the fact that very few families had children under 5 years of age. The proportions of black and white families that did not have any children under 5 years were 68.5% and 71.4% respectively. The families with children in this under 5 group tended to have one or two children rather than three or more. However, 110 of the 145 respondents did have children in schools.

While more blacks were renting their place of residence (55.0% in comparison to 44.6%), more whites owned their homes (55.4% in comparison to 42.7%). Similar differences can be seen with respect to the exterior condition of the residences. Proportionally more white homes were in good condition (33.9% compared to 28.1%). However, the differences on both accounts were rather small.

Population Description by Social Indices

This section describes the respondents in terms of three indices which are privacy, casual neighboring and neighborhood solidarity. The neighboring dimensions attempt to describe the degree of homogeniety and compatability between neighbors as an influencial factor in their satisfaction and predisposition toward relocation (4).

Neighborhood solidarity(5) is described as the perception of social cohesiveness in a given area and the mutual concern of residents for each others welfare. Casual neighboring(6) is the predisposition to enter into friendly relations with neighbors in terms of mutual aid. Privacy implies freedom from observation and association with others within the domain of the dwelling as well as the residential area.

Dwelling and Neighborhood Satisfaction and Expectations

Scales were developed to measure residential satisfaction as well as expectations associated with an "ideal" environment. The data were analyzed to show relationships between the three measures stated above, as well as the relationships between the statements within the four sets used to develop the scales.

The scales were based on the respondents answers to statements dealing with various attributes of the dwelling and neighborhood. The respondents rated each statement as satisfactory or unsatisfactory and a satisfaction score was assigned to each respondent using the following formula: (7)

$$\frac{\text{Satisfactory Items - Unsatisfactory Items}}{\text{Total Number of Items}} \times 100 = \text{Satisfaction Score}$$

The evaluative statements were also used to develop a measure of what the respondents considered important in their ideal dwelling and neighborhood. The five alternative responses for each statement were coded into categories of low, medium, and high.

Interrelationships Between Scales

The data indicates that high satisfaction with the dwelling tends to accompany high satisfaction with the neighborhood (Table 1). For example, of the 63 respondents who scored high on Dwelling Satisfaction (DS), 55.5% scored high on Neighborhood Satisfaction (NS). Most of those who indicated less satisfaction with their dwelling had either medium satisfaction (47.7%) or low satisfaction (31.8%) with their neighborhood too. Respondents with low levels of satisfaction (Table 8) with their dwelling rated those attributes as "very important" in their "ideal dwelling."

Table 1: Respondents Classified by Their Scores on Neighborhood Satisfaction (NS) Index and Dwelling Satisfaction (DS) Index (chi-square significant at .01)

	Dwelling Satisfaction (DS)					
Neighborhood Satisfaction (NS)	High		Medium		Low	
	No.	%	No.	%	No.	%
High	35	55.5	20	52.6	9	20.5
Medium	28	44.5	17	44.7	21	47.7
Low	0	0.0	1	2.7	14	31.8
Total	63	100.0	38	100.0	44	100.0

Table 2: Respondents Classified by Their Scores on Dwelling Ideal (DI) and Dwelling Satisfaction (DS) Index (chi-square significant at .01)

	Dwelling Satisfaction (DS)					
Dwelling Ideal (DI)	High		Medium		Low	
	No.	%	No.	%	No.	%
High	20	31.7	20	52.6	30	68.2
Medium	25	39.6	13	34.2	12	27.3
Low	18	28.7	5	13.2	2	14.5
Total	63	100.0	38	100.0	44	100.0

Neighborhood Attributes

Indications are that the respondents had some clear ideas of the important attributes that an ideal neighborhood should have such that their preferences were not simply reflections of existing dissatisfactions.

Of the 145 respondents, the number that considered fire protection service "very important" was higher than for any other attribute (Table 3). Other attributes considered very important by more than half of the respondents were police protection, good schools, regular trash collection, safe areas for young children, friendly neighbors, health service, good streets, and street lighting, schools within walking distance and convenient distance to church. Clearly then, the important neighborhood attributes can be classified "conveniences." The architectural features of the neighborhood, such as physical privacy, play areas, and landscaping lie in the hierarchy of importance below services.

Table 3: Relationship Between Attributes Considered Satisfactory and Unsatisfactory in the Present Neighborhood and Those Considered "Very Important" in the Ideal Neighborhood

		Satisfactory in the Present Neighborhood			Unsatisfactory in the Present Neighborhood			
Rank Order	Neighborhood Attributes	Very Important in the Ideal Neighborhood	% of all Who Considered It Satisfactory in the Present Neighborhood	N(Base of %)	Very Important in the Ideal Neighborhood	% of all Who Considered It Unsatisfactory in the Present Neighborhood	N(Base of %)	Total N for Very Important
1	Fire Protection	102	78.5	130	13	86.7	15	115
2	Police protection	84	75.7	111	30	88.2	34	114
3	Good quality schools	101	77.7	130	10	76.9	13	111
4	Regular trash collection	85	73.9	115	25	86.2	29	110
5	Safe areas for young children**	35	63.6	55	75	86.2	87	110
6	Friendly neighbors	87	71.9	121	19	79.1	24	106
7	Health services	75	68.8	109	28	80.0	35	103
8	Good streets and street lighting	53	64.6	82	46	73.0	63	99
9	Play areas for children**	27	41.9	63	63	76.8	82	90
10	Easy to get job	67	60.9	110	18	62.1	29	85
11	Privacy from neighbors	65	56.0	116	20	74.1	36	85
12	Convenient walking distance to shopping**	55	56.1	98	25	53.2	47	80
13	Schools within walking distance*	40	46.0	87	37	63.9	57	77
14	Convenient distance from church	66	52.4	126	9	47.3	19	75
15	Child Care center	47	43.9	107	25	67.6	37	72
16	Protection from street noises**	19	25.3	75	47	67.2	70	66
17	Trees near house	42	38.2	110	16	45.7	35	58
18	Convenient distance from friends	44	34.4	128	4	33.3	15	49
19	Convenient distance from relatives	30	24.8	121	9	37.5	24	39
20	Parking in front of home	24	23.3	103	11	26.8	41	35

*Chi-square significant at .05 – **Chi-square significant at .01

The next major issue was the impact of the present neighborhood, particularly with regard to unsatisfactory aspects, upon the section of those items described as "very important" in the ideal neighborhood. Generally, there has been little effect. For example, from the respondents who considered fire protection "very important" in their ideal neighborhood, 78.5% considered fire protection "satisfactory" in their present neighborhood. Similar results were seen with regard to all other attributes rated very important by a majority of the respondents, with the exception of safe areas for young children and play areas for children. In these two cases, the majority of the respondents who considered the attributes very important in their ideal neighborhood, considered them unsatisfactory in their present neighborhood.

These data seem to indicate that the respondent's preferences were not simply reflections of present dissatisfactions or replications of their present situation. However, the probability of considering certain attributes as "very important" was higher among those who consider those same characteristics unsatisfactory in their present neighborhood. For example, 86.7 per cent of those who considered fire protection unsatisfactory in their present neighborhood considered fire protection "very important" in the ideal neighborhood compared to 78.4 per cent among those who considered fire protection satisfactory in their present neighborhood.

Dwelling Attributes

From the 17 attribute statements, the number of respondents considering an attribute "very important" ranged from a maximum of 103 for "comfortable temperature" to 39 for "separate dining room" (Table 4). Ten of the seventeen attributes were considered very important by a majority of the respondents and the remaining seven by less than the majority. Attributes considered very important in descending order were, "size of rooms," "outside appearance of house," "backyard," "front yard," "large kitchen with eating areas," "privacy for each member of the family," "layout of rooms," and "not being bothered by street noises."

The relationship between an attribute being considered unsatisfactory or satisfactory and its being considered very important in rating the ideal dwelling is essentially similar to the neighborhood responses reported previously. A majority of the respondents who considered an attribute "very important" in their description of the ideal dwelling did not necessarily comprise a majority of those who found the attribute unsatisfactory in their present dwelling.

The probability of considering an attribute very important in the ideal dwelling was higher among those whose dwellings were rated unsatisfactory along that dimension than among those whose dwellings were described as satisfactory. For example, 54 of the 103 respondents who considered comfortable temperature "very important" thought that their present home was satisfactory in this dimension. However, 89.1 per cent of those who judged their present dwelling unsatisfactory in terms of "comfortable temperature" considered this to be very important, compared to 60.0 per cent among those who judged their present dwelling to be satisfactory.

The three most important "unsatisfactory" items in the respondent's present dwelling are also the three most "very important" attributes for an ideal dwelling, namely comfort, size, and appearance.

Predisposition Towards Relocation Related to Social and Environmental Variables

Previous research suggests the importance of the physical environment as an extension of the dwelling unit for low-income families where the residential area provides the locus of social networks. This is reinforced by studies that describe actions of grief and extended periods of depression resulting from forced relocation. Dislocation appeared to fragment group identity as well as indicate the critical role of non-housing considerations in the process of urban change. The reality of a "local neighborhood" was an important question and focus of the research by Arthur Little, Inc.(8) Results from their resident attitude survey in San Francisco suggest that friendliness of neighbors and conveniently located local stores reinforce the residents' perceptions of an area as a local neighborhood. Low-income families tend to consider their residence as part of a "local neighborhood" because they participate in it.

Therefore, it appeared to be evident that perdisposition towards relocation may be influenced by physical as well as social factors and that superficial measures, such as dilapidation, as criteria for change may have deleterious consequences on the residents. It becomes obvious that any such arbitary decisions which explicity or implicitly cause relocation may have serious implications. Rather, these decisions must be made on the basis of empirical evidence gathered which the following analyses are aimed at.

When asked whether they would like to "relocate," 58.0% (84) of the respondents indicated that they would. The decision however, appeared to be related to many factors. The desire to re-

Table 4: Relationship Between Attributes Considered Satisfactory or Unsatisfactory in the Present Dwelling and Those Considered "Very Important" in the Ideal Dwelling

		Satisfactory in the Present Dwelling			Unsatisfactory in the Present Dwelling			
Rank Order	Dwelling Attributes	Very Important in the Ideal Dwelling	% of all Who Considered It Satisfactory in the Present Dwelling	N(Base of %)	Very Important in the Ideal Dwelling	% of all Who Considered It Unsatisfactory in the Present Dwelling	N(Base of %)	Total N for Very Important
1	Comfortable temperature in the house**	54	60.0	90	49	89.1	55	103
2	Size of rooms*	46	56.1	82	52	82.5	63	98
3	Outside appearance of house	48	60.8	79	45	69.2	65	93
4	Backyard*	62	55.9	111	28	87.5	32	90
5	Front yard*	54	54.5	99	33	75.0	44	87
6	Front porch**	46	51.7	89	37	68.5	54	83
7	Large kitchen with eating area	45	50.6	89	37	60.7	61	82
8	Privacy for each member of the house	54	49.5	109	24	68.6	35	78
9	Layout of rooms**	42	42.4	99	35	76.1	46	77
10	Not being bothered by street noises**	29	34.1	85	44	74.6	59	73
11	Cross-ventilation*	46	44.2	104	25	75.8	33	71
12	Separation of children's and parent's areas**	39	36.1	108	28	82.4	34	61
13	Outside storage**	29	34.9	83	30	49.2	61	59
14	Inside children's play area**	25	24.4	88	33	66.0	50	58
15	Morning sunlight**	40	31.5	127	9	60.0	15	49
16	Carport**	10	12.9	77	37	56.9	65	47
17	Separate dining room**	11	13.8	80	28	44.4	63	39

*Chi-square significant at .05
**Chi-square significant at .01

locate was related to the respondents level of satisfaction, both with his present dwelling and present neighborhood. The data indicates that increasing degrees of satisfaction corresponded to the increasing probability that the individual would not want to relocate. The proportions wanting to relocate increased from 51.6% (Table 5) among those who indicated higher levels of satisfaction with the neighborhood to 73.3% who indicated low levels of satisfaction. The relationship between the desire to relocate and level of satisfaction with the dwelling seems more apparent. The corresponding proportions increased from 38.1% to 88.1% showing that satisfaction with the dwelling is a more important determinant of desire to relocate than satisfaction with the neighborhood.

It is significant to note that there were respondents with low satisfaction scores, who did not want to relocate and others with high levels of satisfaction who wanted to relocate. For further clarification, two social indices were analyzed, which tested for possible relationships between the desire to relocate and "neighborhood solidarity," "casual neighboring," "neighborhood satisfaction," and "dwelling satisfaction."

Table 5: Respondents Classified by Their Willingness to Relocate and High Scores on Environmental Indices

	High Neighborhood Solidarity		High Casual Neighboring		High Neighborhood Satisfaction		High Dwelling Satisfaction	
Relocation	No.	%	No.	%	No.	%	No.	%
Yes	8	44.4	23	62.2	33	51.6	24	38.1
No	10	55.6	14	37.8	31	48.4	39	61.9

The "neighborhood solidarity index" which indicates the level of an individual's involvement with others in the neighborhood and his perceptions of neighbors' concern with his life shows a definite relationship with the desire to relocate. For example, 44.4% (Table 5) of the respondents who perceived a high degree of solidarity in the neighborhood desired to relocate, the corresponding proportion for those who perceived low solidarity was 73.4% (not shown in table).

Race and Relocation

Compared to whites, a greater proportion of blacks indicated a willingness to relocate, the proportions being 61.8% and 42.9% (Table 6). This is understandable since comparatively more blacks indicated low satisfaction with their existing dwelling and neighborhood. For example, while 37.1% of the black respondents indicated low satisfaction with their present dwelling, the corresponding proportion for whites was 21.5%. The differences in neighborhood satisfaction was more apparent. The proportion who had a high level of satisfaction with the neighborhood were 33.7% for blacks and 60.7% for whites.

Table 6: Respondents Classified by Their Willingness to Move and Race

	Black		White	
Relocation	No.	%	No.	%
Yes	55	61.8	24	42.9
No	34	38.2	32	57.1
Total	89	100.0	56	100.0

All respondents, irrespective of whether they indicated willingness to relocate, were asked to choose one of four possible neighborhoods they would prefer to relocate in if they decided to move. The four locations were "North Asheboro," a predominantly white section; "East Salisbury," a predominantly black low-income section; the "Peachtree and Church Street Area," a predominantly white neighborhood; and the "New High School Section," a predominantly white upper income area. The results are quite interesting, though consistent with our expectations.

Although, some blacks indicated a preference for relocation in white sections and a few whites indicated a preference for black sections it was significant that most respondents selected locations inhabited by members of their own race. More than half (51.7%) of the black respondents names the "East Salisbury Street Area" and only 14.3% of the white respondents selected this area as their preference. Comparatively fewer white respondents indicated a willingness to relocate. The data represent the responses to the hypothetical question, "How would you improve your place of living if you had sufficient money?"

Of the three options, a significantly larger proportion of the whites indicated that they would make their place of living better by "improving their present home." Greater proportions of black respondents would better their place of living by buying (52.8%) or renting new housing (13.5%).

Decision to Relocate and Acceptable Trade-Offs

A series of questions were asked of the 84 respondents willing to relocate in order to identify the factors influencing their decision to relocate based on personal gains and losses incurred in the process. While all the possible advantages and disadvantages of relocation were not included, the statements were based on Trade-offs between opposite categories. The first category included "higher cost" (or rent), "losing old neighbors" and "moving away from the present church." The second category included "gaining more space," "gaining new neighbors," "possibility of home ownership" "gaining more outdoor recreational area."

The data in Tables 7 and 8 indicate that within the framework of the trade-offs suggested, most of the respondents who had initially indicated a desire to relocate were still of the same opinion. This is important since it shows that people are willing to relocate even if it costs more or causes certain inconveniences or disruptions in their life styles. Moreover, with each possible trade-off the results are variable.

From the results in Table 7, it can be seen that relocation to more costly housing was more acceptable if the relocations could help "gain more space" (79.7%) or possibly entail home ownership (64.3%), as compared to situations where spending more, families would "gain more outdoor recreational area" (79.7%) or "new neighbors" (52.4%).

Table 7: If Home Cost More, But You

	Gain More Space**		Gain New Neighbors		Gain More Outdoor Space**		Own the Home*	
Willingness to Move	No.	%	No.	%	No.	%	No.	%
Yes	67	79.7	44	52.4	67	79.7	54	64.3
No or undecided	17	20.3	40	47.6	17	20.3	30	35.7
Total	84	100.0	84	100.0	84	100.0	84	100.0

A majority of the respondents who had initially indicated a desire to relocate would accept losing their present neighbors if they perceived advantages in relocating (Table 8). Of the four possible advantages, owning a home seemed desirable to more people (80.9%).

Table 8: If You Lose Old Neighbors, But You

	Gain More Space**		Gain New Neighbors*		Gain More Outdoor Space**		Own the Home**	
Willingness to Move	No.	%	No.	%	No.	%	No.	%
Yes	56	66.7	53	63.1	53	63.1	68	80.9
No or undecided	28	33.3	31	36.9	31	36.9	16	19.1
Total	84	100.0	84	100.0	84	100.0	84	100.0

*Chi-square significant at .05
**Chi-square significant at .01

Similarly, the possibility that relocation might involve moving away from their present church did not deter a majority from the desire to relocate. Again, the advantages sought by most of the respondents were home ownership (75.0%) and more space (69.0%).

Residential Silhouette Preference
The respondents were shown seven different residential silhouettes and asked to rank them in order of their preferences. The set included house types most common to many residential areas of North Carolina(Numbers 1, 2, and 5) as well as unfamilar types (Figure 1).

The data indicate that picture #1 and #5 were the most preferred. While picture #1 received 61 first choices, picture #5 received 45 first choices. For two out of every three respondents, these house types were no lower than their third choice. Pictures #3, #6, and #4 seem to be the least preferred. For example, for 70.4% of the respondents, picture #4 ranked as their fourth or lower choice. Picture #6 was ranked similarly by 68.3% of the respondents. Although pictures #1 and #5 were the most preferred, there is no reason to suggest

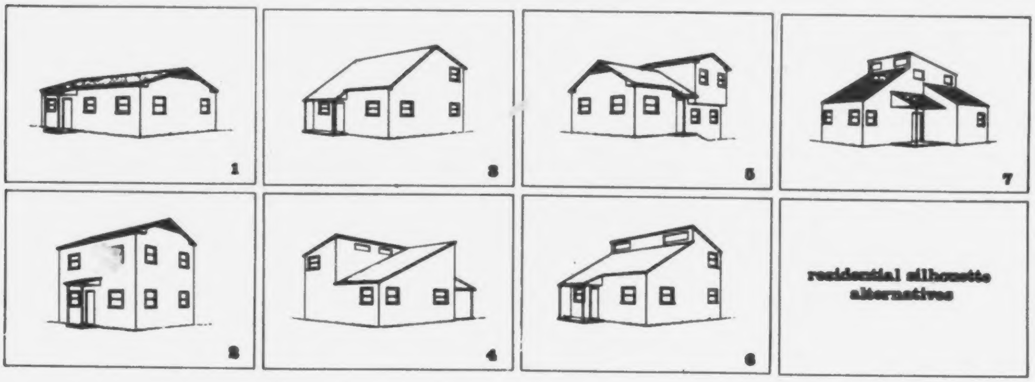

Figure 1. Residential Silhouette Alternatives

Table 9: Respondents Classified By Their Preference For House Type and By Race and Income (Chi-square significant at .05)

	INCOME													
	Up to 2999			3000 4999			5000 6999			7000 & over				
House Type	All	Black	White	All	Black	White	All	Black	White	All	Black	White	All Black	All White
1	29 47.5	18 40.0	11 68.7	13 50.0	8 44.5	5 62.6	7 35.0		7 58.3	12 35.3	3 18.6	9 50.0	29 33.3	32 59.2
2	5 8.2	5 11.1		1 3.8		1 12.8	2 10.0	1 12.5	1 8.4	1 2.9	1 6.3		7 8.0	2 3.8
3	2 3.2	1 2.2	1 6.3	1 3.8	1 5.5					5 14.7	2 12.5	3 16.7	3 4.1	5 9.3
4	2 3.2	2 4.4		1 3.8	1 5.5					1 2.9	1 6.3		4 4.6	
5	15 24.6	12 26.6	3 18.7	8 30.9	7 39.0	1 12.8	10 50.0	6 75.0	4 33.3	12 35.3	8 50.0	4 22.2	33 37.9	12 22.2
6	4 6.6	3 6.7	1 6.3										3 4.1	1 1.9
7	4 6.6	4 9.0		2 7.7	1 5.5	1 12.8	1 5.0	1 12.5		3 8.9	1 6.3	2 11.1	7 8.0	3 5.6
Total	61 100.0	45 100.0	16 100.0	26 100.0	18 100.0	8 100.0	20 100.0	8 100.0	12 100.0	34 100.0	16 100.0	18 100.0	87 100.0	54 100.0

that they were equally preferred by all income groups and both racial groups.

Picture #1 which received first choice from 43.2% of all respondents, received first choice of 59.2% of the blacks and 33.3% of the white respondents. Among the four income groups, it was preferred as first choice by proportionately more respondents from the two lower income groups. While for one-half of the respondents with incomes under $5,000 #1 was their first choice, the corresponding proportions for the two higher income groups were 35.0% and 35.3% (Table 9).

Pictures #3, #4, #6, and #7 suggest a range of modern alternatives that are not accessible to low-income families. Approximately one-fifth (17.9%) of the sample group indicated a first preference for one of the designed alternatives, suggesting a potential market for other than traditional house types.

Housing Arrangement Preferences

Four hypothetical site planning alternatives were presented to the respondents to rate in terms of: "best for privacy," "raising children," "exterior design," "contact with neighbors," and "to do the things you want." Each of the alternatives represents an abstraction of the diversification possible in the nation today. Housing arrangement #1 describes four family clusters; #2 suggests single family occupancy with private enclosed areas, #3 illustrates duplex units with private enclosed areas, and #4 is single family with private outdoor areas (Figure 2).

The data in Table 10 describe the alternatives and the distribution according to each of the evaluative criteria. Housing arrangement #2 was preferred most as best for privacy (36.6%) and the best to do the things you want (37.9%).

Table 10: Respondents Classified by Their Assessments of Housing Arrangements

Housing Arrangements	Best for Privacy** No.	%	Best for Raising Children** No.	%	Best Exterior Design** No.	%	Best Contact with Neighbors** No.	%	Best to do the things You Want No.	%
1	28	19.3	30	20.7	28	19.3	45	31.0	31	21.4
2	58	36.6	36	24.8	41	28.3	30	20.7	55	37.9
3	24	16.6	13	8.9	20	13.8	14	9.7	14	9.7
4	31	21.4	53	36.7	44	30.3	46	31.7	34	32.4
No response	9	6.1	13	8.9	12	8.3	10	6.9	11	7.6
Total	145	100.0	145	100.0	145	100.0	145	100.0	145	100.0

**Chi-square significant at .01

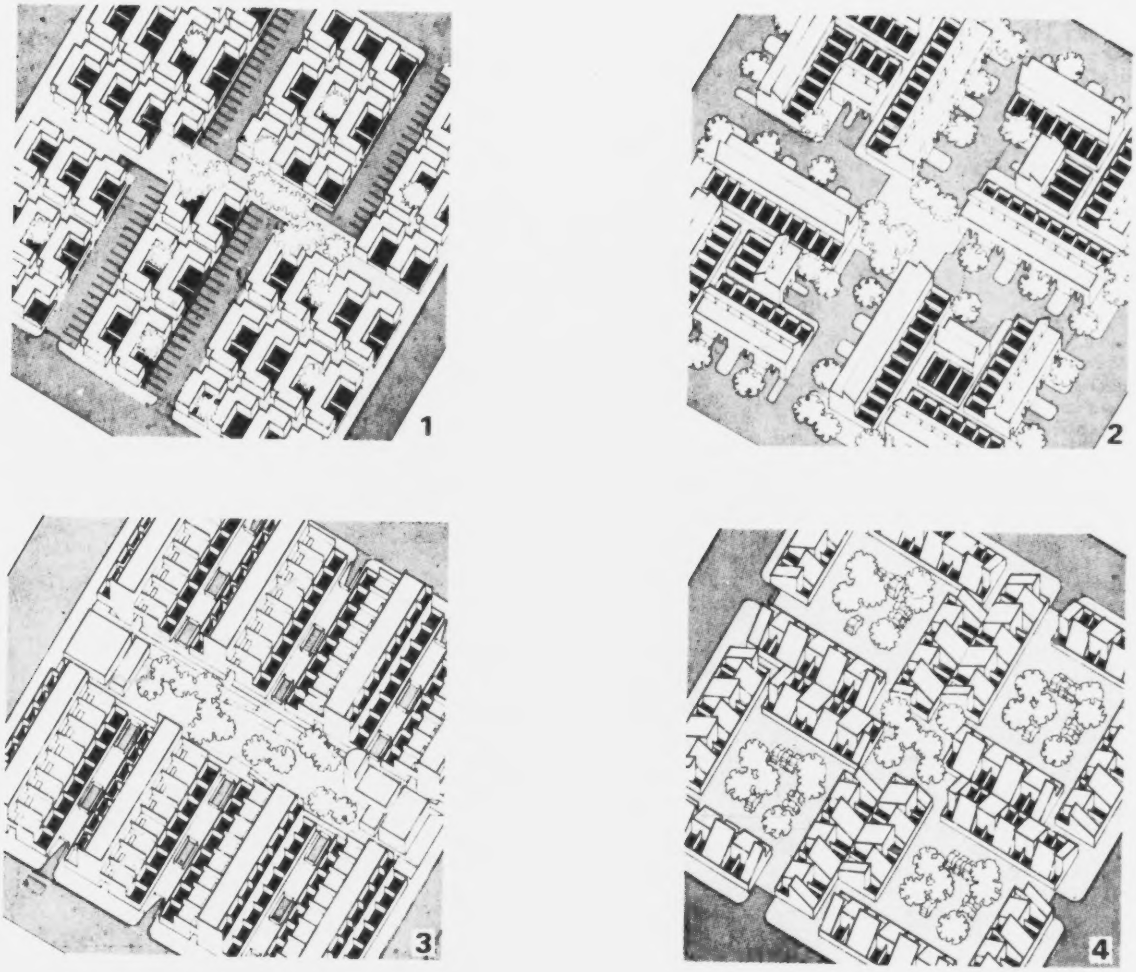

Figure 2: Housing Arrangement Alternatives

Arrangement #4, which clearly articulates an interior court, was rated best for raising children (36.7%), exterior design (30.3%) and contact with neighbors (31.7%). It is noteworthy that housing arrangement #3, which typifies planned residential development, was preferred least in each of the five categories.

Summary and Conclusions

Since the objective of most environmental studies, including this one, is to predict the influence of the environment on man and his response to an evaluation of it and to control environmental influence on man to make it most consistent with his values and life styles, the findings of this study have some important implications for design and planning decisions. First, the study provides further evidence in support of the notion discussed in an earlier part of this report that a dwelling or neighborhood that would be considered ideal by people of all backgrounds is an impossibility. The preferences for home and neighborhood design are reflections of a variety of social, economic, psychological, and cultural factors.

Second, an individual's satisfaction with his dwelling is generally associated with his level of satisfaction with his neighborhood. This emphasizes the fallacy of policies geared to designing acceptable housing without considering the social environment or context of the housing.

Third, low-income people with generally limited education do have clear ideas as to what they prefer in their house and neighborhood. Their preferences are not simply the manifestations or reflections of what they do not presently have. The data show that in neighborhood design, low-income families consider "services" more important than conveniences, and in dwelling design they consider dimensions like proper room temperature control, size of room, outside appearance, backyard, etc., more important than cross-ventilation, separation of parent's and children's areas, morning sunlight, carport, and separate dining area. The basic aspects of comfort, function, and image are the salient needs described by this population. Discrimination between planning alternatives becomes a relevant factor when the very basic needs are satisfied.

Fourth, low-income families are not necessarily interested in relocation just because they are not satisfied with their present homes or neighborhoods. When relocation is desired, both whites and blacks wish to relocate to areas dominated by members of their own race. Franklin Frazier points out, separate community life causes many blacks to develop a vested interest in segregation (9). Similarly, the all-black church and other black institutions thrive best in a racially segregated society. Consequently, there is every reason to expect that even when racial discrimination ends and blacks, as a group, find it economically feasible to afford a wide range of housing, there will be binding ghetto ties that restrain many blacks from moving to interracial areas. This view is supported by research findings from middle-income blacks living in Boston, where a small fraction of these families seriously considered living in the predominantly white suburbs, despite the fact that they were in the path of urban renewal (10).

The results also indicate that people wishing relocation would accept relocation even when they foresee the possibility of spending more money if the trade-offs involved are consistent with their needs and preferences. For example, relocation involving increased expenses is more acceptable when people stand to gain more space or ownership than when trade-offs involve gaining more recreation area or new neighbors.

Fifth, visual preferences are mostly restricted to prevailing types of dwellings. While innovative designs do not evoke enthusiastic responses, it is clear that a wider range of design alternatives and dwelling arrangements would satisfy the diversity of the population's needs.

Sixth, most people prefer housing arrangements that are single family dwellings with a private enclosed area. The need for an individual to maintain his identity and autonomy is reflected in the preferences for solutions that permit this within the dwelling as well as the need for a territorial extension beyond the dwelling.

The current dilemma of the "creeping" monotony of designed residential environments, especially for the poor, could easily be circumvented if design and planning decisions were more consistent with the wide range of users' needs and expectations. Assumptions of what ought to occur need to be considered in concert with what ought not occur if we are ever to achieve our housing goal consistent with the users' satisfactions.

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AN ARCHITECTURAL SURVEY OF HOW SIX FAMILIES USE SPACE IN THEIR EXISTING HOUSES

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Background and Objectives

All housing proposed by public action must pass restrictive budgets and program requirements before houses can be built and occupied. The absence of relevent architectural programs makes it difficult to determine which elements of design must be retained and which can be eliminated without sacrificing the needs of the dwellers since these programs are established without consulting people that might be occupying the housing and therefore designs are often not related to the life style of the families or to the living patterns of the community.

To develop better programs for other community needs, the New Haven, Connecticut Redevelopment Agency has been obtaining survey information about the housing it sponsors. As architects for the NHRA's 236 cooperative housing project known as Harmony House, we requested that in addition to the information needed by the NHRA's staff, the survey described by this paper attempt to record the housing needs of the potential users.

This paper is the result of that survey which was timed to take advantage of a unique situation. The working drawings for our housing commission were virtually completed but, because of increased construction costs, the estimates were considerably over the budget and it was apparent that the only means of reducing costs was a redesign. We were prepared to accept entirely new design criteria and felt that this was an important opportunity to test the effectiveness of responding to what the potential user says it wants and needs.

We felt the results from even a limited survey would help us determine needs for size, location and use of space in the main living areas of the houses. We also had a feeling, from the beginning of the project, that we had accepted criteria for the design of the space, from the various institutional clients involved, which was not related to the existing life style of the potential users.

Thus we wanted, in a simple way, to provide some programmatic guides for us to establish key architectural relationships. In addition, we needed a device to objectify our intuitions about occupant use and preference in a way which could be communicated to the institutional client.

In addition we saw the survey as a means of establishing post occupancy evaluation criteria which, after construction and occupancy, could provide meaningful feedback and a check on our design evaluation.

Summary of Sample Family Situation

The families live in a very casual and informal manner. Much of the living takes place in the kitchen which serves as an informal gathering or meeting place for family and friends. Usually, formal meals are not served and there is a constant flow of people in and out of the kitchen. Most of the home entertaining is also informal. On Sundays, neighbors often visit each other after church. Since the usual family is large, both the living room and the kitchen are used to accommodate guests. The children generally play in any available space in the apartment, most often in the kitchen and bedrooms, the living room being occupied by the adults. The day is also spent watching television, playing cards, listening to music, cleaning cars, and conversing.

Most of the people either presently live, or have lived in overcrowded conditions. They are used to being with many people all the time. Therefore, they value a certain amount of privacy, and usually reject community or shared facilities, except play areas for children. If the families spend time outside, they would rather do so in a small fenced backyard

Since many families have small children, the yard is used as a play area where the children can be easily watched. While desiring privacy, the sample also like to take an active part in community life, and there is much interaction among neighbors. The people enjoy sitting on their front porches talking with neighbors and watching street activity.

The principle desire of all those interviewed was to have a home in which there was enough free space, especially in the kitchen area, to accommodate the many varied activities of a large family while maintaining a feeling of openness and freedom of movement.

Survey Test Plan

The plan shown in Figure 1 was used as the vehicle for conducting the interviews. Figure 2 is our final plan illustrating the changes resulting from the survey.

The following six pages show, on the left existing housing as the survey found it and on the right the survey test plan as it was altered by that family.

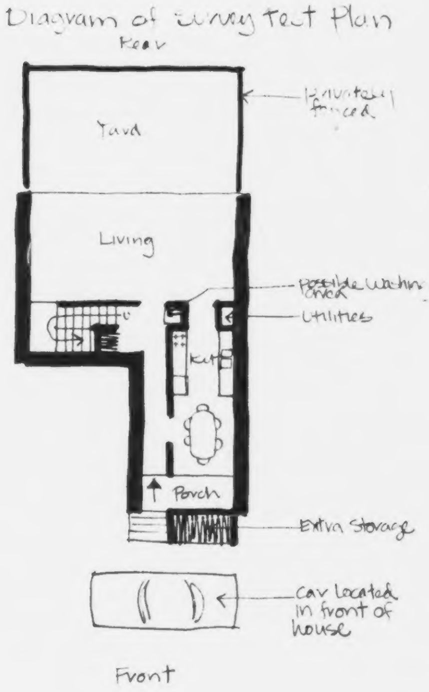


Diagram of Survey Test Plan
Rear
Yard
Privately fenced
Living
Possible washing area
Utilities
Kit
Porch
Extra Storage
Car located in front of house
Front

Figure 1. Architects' Plan Before Survey

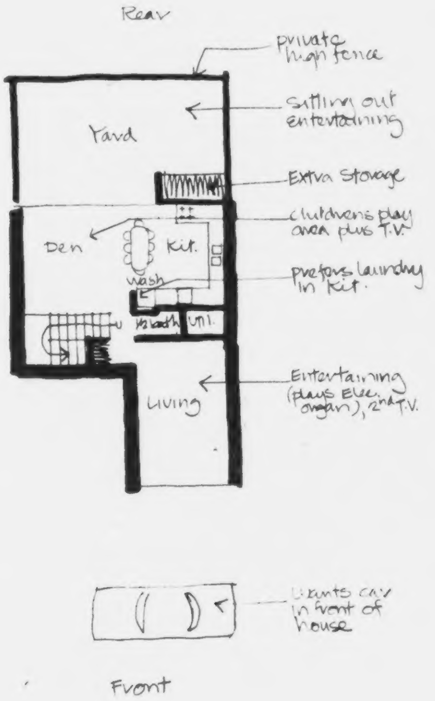

Rear
private high fence
Yard
Sitting out entertaining
Extra Storage
Den
Kit.
childrens play area plus T.V.
wash
prefers laundry in Kit.
½ bath
Util.
Living
Entertaining (plays Elec. organ), 2nd T.V.
Wants car in front of house
Front

Figure 2. Architects' Plan After Survey

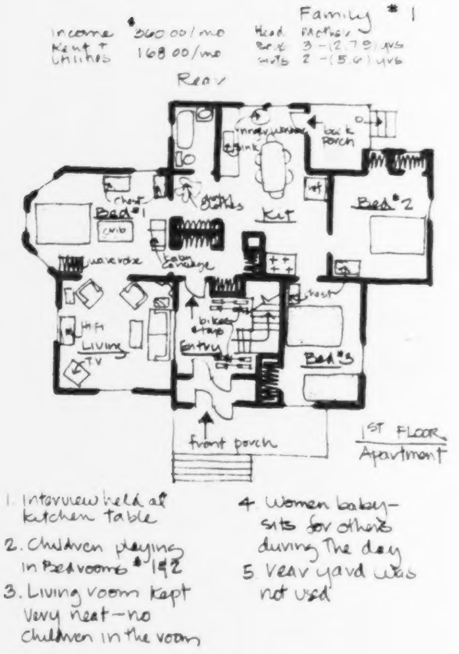

Family # 1
Income $360.00/mo
Rent + Utilities 168.00/mo
Head Mother
Girls 3-(2,7,9) yrs
Boys 2-(5,6) yrs
Rear
wringer washer
sink
back porch
chest
Bed #1
crib
dirty clothes
Kit
ref
Bed #2
wardrobe
baby carriage
chest
HiFi
bikes etc.
Living
TV
Entry
Bed #3
front porch
1st FLOOR Apartment
1. Interview held at kitchen table
2. Children playing in Bedrooms # 1&2
3. Living room kept very neat - no children in the room
4. Women baby-sits for others during the day
5. Rear yard was not used

Figure 3. Existing House

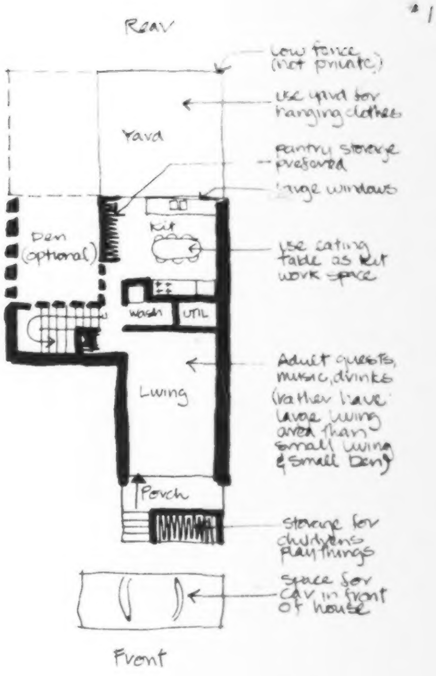

# 1
Rear
Low fence (not private)
Use yard for hanging clothes
Yard
Pantry storage preferred
Large windows
Den (optional)
Kit
Use eating table as kit work space
wash
UTIL
Adult guests, music, drinks (rather have large living area than small living & small Den)
Living
Porch
Storage for children's play things
Space for car in front of house
Front

Figure 4. Architects' Altered Plan

A female head of household was interviewed. Younger children were present but did not participate. Woman friend was present and participated in the survey.

1

Kitchen
She desired a big kitchen in the back of the house, with a door to screen the kitchen from the living room - as long as the door opened either way. One person prepares all three meals and seems to spend most of the day in the kitchen, including washing clothes. She uses the kitchen table as a work area as there is little counter space and she enjoys working sitting down. In addition, entertainment frequently is in the kitchen around the table. She would like kitchen cabinets if they are low enough to reach, would like a pantry, 6' counter space and a large stove, automatic washer in kitchen and lots of windows.

Dining
Family likes to eat in center of kitchen and wants kitchen dining room separate from living room.

Living
Living room is used to entertain friends. Family would prefer to have a special space for television and kids to play but, doesn't want the area open to the kitchen (i.e., want a separate room) and if given a choice between two small rooms for living and TV or nice size living room, would give up TV room. Children play all over the house but, not in the living room. Family would like a basement room for children's play with a possible laundry, and were very enthusiastic about a two story house.

Outside
Family does not have a car, but thinks it would be better in front of house, not in a shared lot.

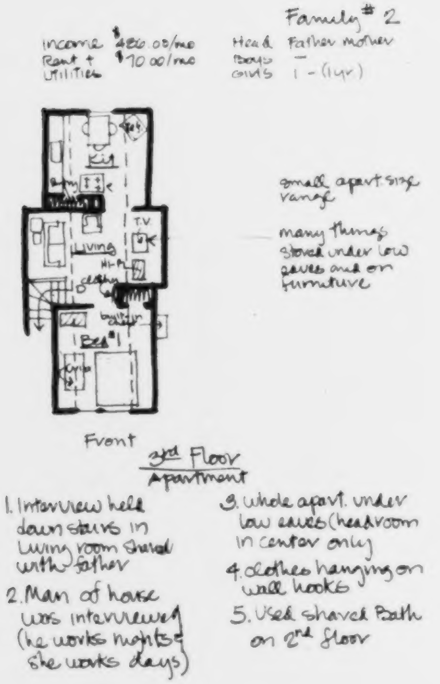

Family # 2
income $486.00/mo
Rent + Utilities $70.00/mo
Head Father mother
Boys —
Girls 1 - (1yr)
Kit
T.V.
Living
Hi-Fi
clothing
built in closet
Bed #1
small apart. size range
many things stored under low eaves and on furniture
Front
3rd Floor Apartment
1. Interview held downstairs in Living room shared with father
2. Man of house was interviewed (he works nights & she works days)
3. whole apart. under low eaves (headroom in center only
4. clothes hanging on wall hooks
5. Used shared Bath on 2nd floor

Figure 5. Existing House

Male head of household was interviewed. Lives on third floor of father's home.

2

Kitchen

Prefers kitchen in rear of house with door to close between kitchen and living room. Would not like front door opening into kitchen dining room. Subject would like a big kitchen, though not a strip. One person prepares two meals/day, but not too much time spent in kitchen, as family tries to get out a lot and both parents work. Family has a pantry and would like kitchen cabinet storage. Six feet of counter okay, but would like on both sides of sink and stove (prefers 24" stove). Family has no washer in kitchen. Would like to have some place in house for washer/dryer but if not would use a central laundry room. Would rather have counter space than kitchen table, since doesn't use table for work space, even though family entertains around kitchen table and "everyone usually ends up in the kitchen."

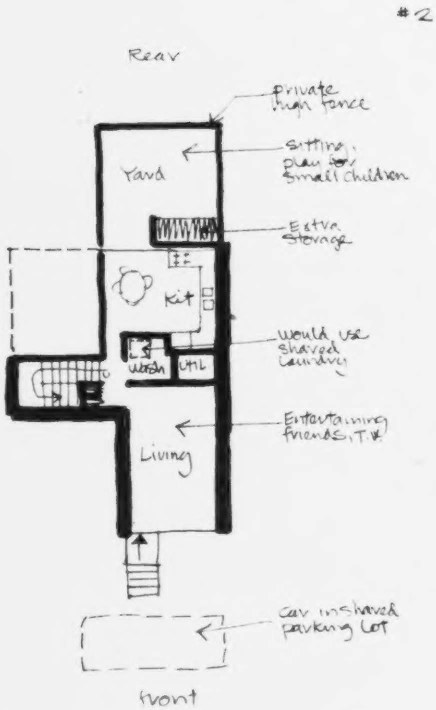

#2
Rear
private high fence
Yard
sitting, play for small children
Extra Storage
Kit
would use shared laundry
Wash
Util
Entertaining friends, T.V.
Living
car in shared parking lot
front

Figure 6. Architects' Altered Plan

Dining

Doesn't need separate room. Would rather have a separate living room which would not see the kitchen and eating area.

Living

Living space used for both TV and friends. Felt separate space not necessary. Child plays indoors in kitchen-dining, and toys are kept in kitchen. Did not consider special location of child's play area important, but felt two story house would be desirable.

Outside

Family owns auto and feels it can be in a lot (car currently parked in lot next to apartment). A back yard was preferred to a front porch, for sitting in private and also for children to be able to play safely.

Bedrooms

Would rather have more smaller rooms (3), since father might live with family. Used bedroom for sleeping and storing clothes.

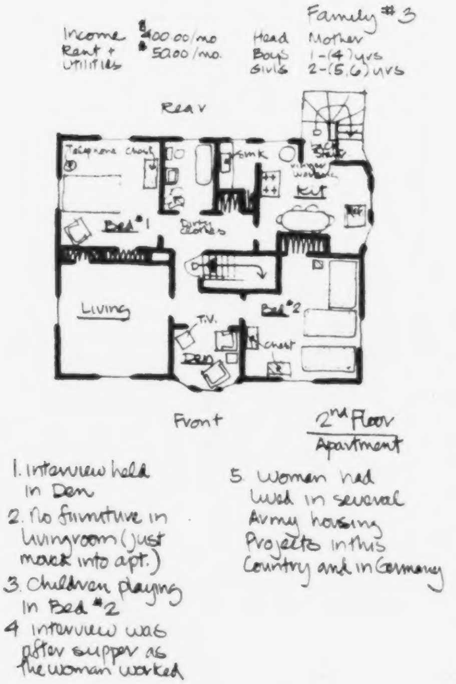

Family #3
Income $400.00/mo
Rent + utilities $50.00/mo.
Head Mother
Boys 1-(4) yrs
Girls 2-(5,6) yrs
Rear
Telephone chair
sink
Kit
Bed #1
Dirty clothes
Living
T.V.
Den
Bed #2
chest
Front
2nd Floor Apartment
1. Interview held in Den
2. No furniture in livingroom (just moved into apt.)
3. Children playing in Bed #2
4 Interview was after supper as the woman worked
5. Women had lived in several Army housing Projects in this Country and in Germany

Figure 7. Existing House

3

Female head of household was interviewed. Small children were present but did not contribute to the survey.

Kitchen

Would like kitchen at rear, not visible from living room, but okay if there is a connecting door. Would not want to enter into the kitchen eating area. Head of house works and only cooks one big meal a day at dinner, although breakfast is also eaten. Prefers pantry to cabinet storage, and strongly felt cabinets over stove no good. 8' of counter, plus appliances, enough but would like a larger range than minimum often found in apartments. Would not like to wash in kitchen if it were larger. Preferred washing out of kitchen but not in basement. Family used a kitchen table, has no counter top space, but would prefer counter top work space. Has used and disliked small efficiency kitchens. Family does not entertain in kitchen, prefers living room. Subject works and does not spend much time in the kitchen.

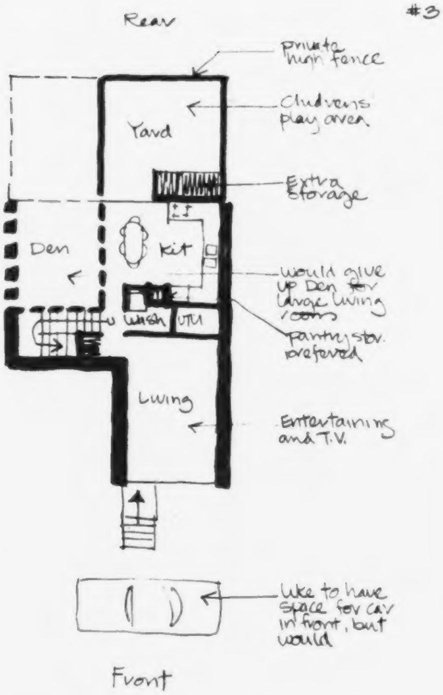

Rear
#3
private high fence
Yard
Childrens play area
Extra Storage
Den
Kit
would give up Den ~~for~~ large living room
Wash
UTIL
Pantry stor. preferred
Living
Entertaining and T.V.
Like to have space for car in front, but would
Front

Figure 8. Architects' Altered Plan

Dining

Prefers dining alcove off kitchen and would not like dining room opening to the living room.

Living

Space used for both friends and TV and felt separate space not necessary. Children play all over the house, but felt a special room near the kitchen for them would be good. Family would like a two-story house with bedrooms upstairs.

Outside

Family doesn't own a car, felt central parking was okay, but would rather have car in front of house. Had no use for a front porch, but felt a back yard would be good for the children to play in, so they wouldn't run loose in the street. A small private rear yard would be used for sitting and child play, but not for hanging clothes (would rather use a dryer).

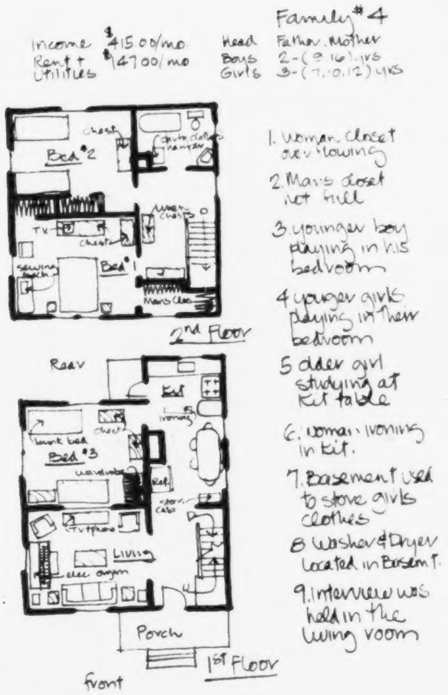

Family #4
Income $415.00/mo.
Rent + Utilities $147.00/mo
Head Father, Mother
Boys 2-(9,16) yrs
Girls 3-(7,10,12) yrs
chest
cloth dollies hamper
Bed #2
Mans chests
TV
chests
sewing mach
Bed #1
Mans Clos
2nd Floor
Rear
Kit
ironing
chest
bunk bed
Bed #3
wardrobe
Ref
storage cab
TV phono
Living
elec organ
Porch
1st Floor
front
1. woman closet overflowing
2. Mans closet not full
3 younger boy playing in his bedroom
4 younger girls playing in their bedroom
5 older girl studying at Kit table
6. woman ironing in kit.
7. Basement used to store girls clothes
8 Washer & Dryer located in Basemt.
9. Interview was held in the living room

Figure 9. Existing House

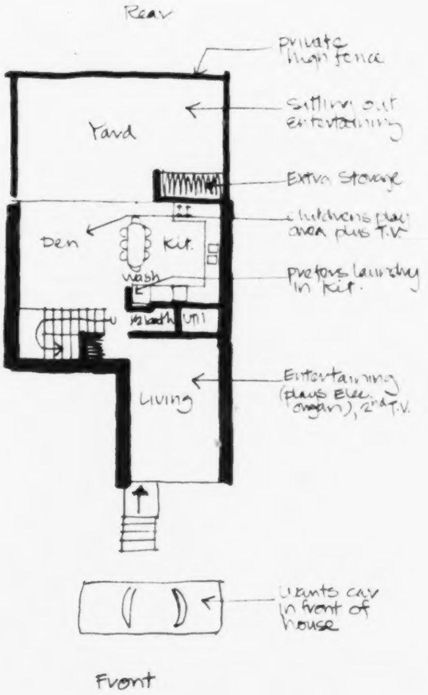

Rear
private high fence
Yard
Sitting out entertaining
Extra Storage
Den
Kit.
childrens play area plus T.V.
wash
prefers laundry in kit.
½ bath
util
Living
Entertaining (plays Elec. organ), 2nd T.V.
wants car in front of house
Front

Figure 10. Architects' Altered Plan

Wife was interviewed, younger children were present but did not participate in the survey.

4

Kitchen

Would like kitchen in rear but not visible from living room. Would not mind entering into kitchen eating area if easy to go to living room too. Wife prepares three meals daily. Prefers wall and base cabinet storage. 6' of counter plus appliance tops enough but wanted larger stove and refrigerator. Would like to wash in kitchen if it were larger. Family entertains around kitchen table, but doesn't use table for work space, prefers counter top. Would like to spend as little time as possible in kitchen.

Dining

Would like to eat in dining alcove off kitchen but felt open living/dining okay, too.

Living

Space used for playing music (electric organ) entertainment, but no TV (TV watched in bedroom). Would prefer separate room for TV even if living room is smaller. Children play in bedrooms and kitchen/dining, not living, but would like a basement room for children's indoor play. Would like to live in a two story house.

Outside

Prefer to park car in front of house, husband just parked there as interviewers leaving. Felt front porch not too important, would give it up for more space inside or a rear yard. The rear yard could be small, but with a high privacy fence and not shared. Children would not play there, but would be a private sitting outside place for adults; children would play in front of the house.

Bedrooms

Would rather have fewer larger rooms than one for each child, but felt needed 3 bedrooms. Mother sews in bedroom and needs alcove for machine. Would like 10' of closet in parents' bedroom and 4' for each child.

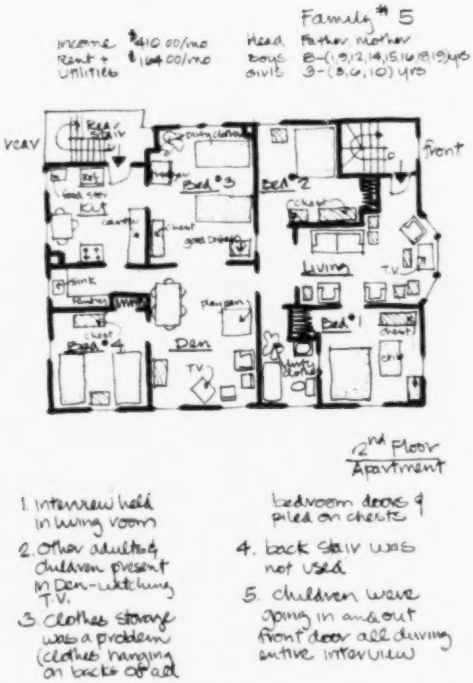

Family # 5
income $410 00/mo
Rent + Utilities $164 00/mo
Head Father mother
boys 8-(1,9,12,14,15,16,18,19) yrs
girls 3-(3,6,10) yrs
rear
Rear Stair
front
Bed #3
Bed #2
Kit
Ref
food stor
counter
chest
good drawers
chest
Living
T.V.
sink
Pantry
playpen
Bed #1
chest
Bed #4
Den
TV
dirty clothes
crib
2nd Floor Apartment
1. interview held in living room
2. Other adults & children present in Den-watching T.V.
3. Clothes storage was a problem (clothes hanging on backs of all bedroom doors & piled on chests
4. back stair was not used
5. children were going in and out front door all during entire interview

Figure 11. Existing House

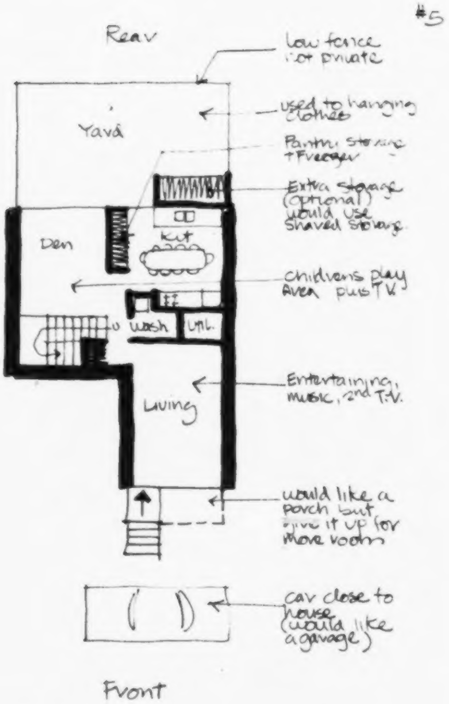

#5
Rear
low fence not private
used to hanging clothes
Yard
Pantry storage + Freezer
Extra storage (optional) would use shared storage
Den
Kit
childrens play Area plus T.V.
wash
Util.
Entertaining, music, 2nd T.V.
Living
would like a porch but give it up for more room
car close to house (would like a garage)
Front

Figure 12. Architects' Altered Plan

Wife was interviewed, younger children were present but did not contribute to the survey.

5

Kitchen

Would like kitchen in rear and visually separate from the living area, with entry into space between kitchen and living. Wife prepares most meals, boys help, kitchen used three meals daily. Need generous storage space, pantry plus wall and base cabinets. Felt 6' of counter was enough, in addition to large appliances. Would not wash in kitchen if it were larger (prefers washing in basement). Entertains in kitchen and would use kitchen table for work space in addition to counters. Wife spends quite a bit of time in kitchen.

Dining

Prefers dining in center of kitchen and would object to dining being open to living area.

Living

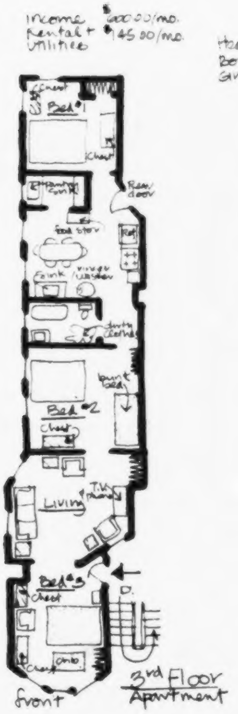
Uses area for sitting and music and prefers toward front of house. Would rather have two small rooms, one for TV than one large living room. Children play all over the house but would like kids to stay out of living room. Would like a separate den for play. Two story house is acceptable with a basement.

Outside

Car close to the house better than a central lot and "husband always wanted a garage." Family doesn't need front porch, would give up porch for space inside or bigger yard in rear. However a small yard okay, but private and fenced low. Would hang wash here and let children play in street.

Bedrooms

Felt basement okay for bedrooms, needed six (one for each child), and would rather have many small ones rather than fewer large ones. Use only for sleep and clothes storage. Felt 6' Closet enough for each room.


Income $600.00/mo.
Rental + Utilities $145.00/mo.
Chest
Bed #1
Chair
Rear door
Pantry sink
food stor
Ref
Sink
wringer/washer
dirty clothes
bunk bed
Bed #2
Chair
T.V. phono
Living
Bed #3
Chest
Chest
crib
front
3rd Floor Apartment

Family #6
Head Father, Mother
Boys 3 - (7, 11, 14) yrs
Girls 3 - (3, 15, 17) yrs

1. interview held in living room
2. older daughters listened
3. rear stair unsafe can't be used
4. Storage a problem (clothes hanging on wall hooks in Bed #2 & 3)
5. Bed #3 used by 2 older girls and oldest girl's baby
6. Family had lived in a housing project.

Figure 13. Existing House

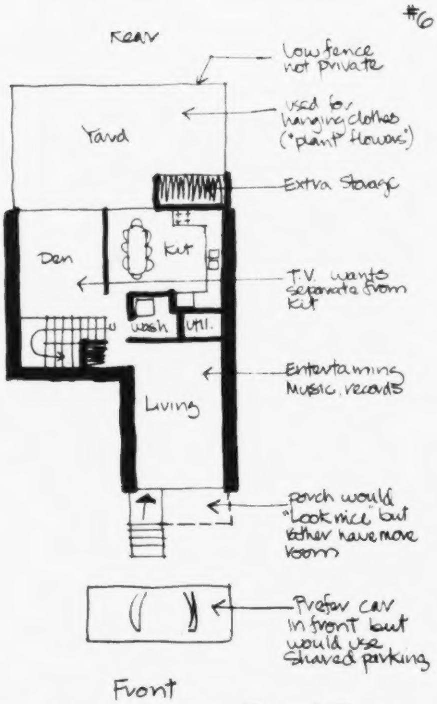

#6
Rear
Low fence not private
Yard
used for hanging clothes ("plant" flowers)
Extra Storage
Den
Kit
T.V. wants separate from Kit
wash
Util.
Entertaining Music, records
Living
porch would "Look nice" but rather have more room
Prefer car in front but would use shared parking
Front

Figure 14. Architects' Altered Plan

Wife was interviewed, husband did not participate.

6

Kitchen

Would like kitchen in rear of house, not open to living room. Entry between living room and kitchen okay. Wife and two older girls prepare three meals daily. Needs ample storage; would like wall cabinets over pantry so children won't have access. Felt 6' counter in addition to large appliances okay. Currently washes in kitchen, but would like washer there. Family doesn't entertain in kitchen. Prefers work surface counter rather than table top.

Dining

Prefer to eat in an alcove not in the center of the kitchen. Would like kitchen/eating separate from living, TV, or den.

Living

Space used for good furniture, record player, entertaining, drinking and card playing. Prefer separate smaller room for TV even if it means smaller living room. Children play all over house but would prefer a basement play room for bad weather. Would like a two or three story house.

Outside

Car preferred in front of house, husband used car for work, wife didn't drive. Porch would look nice but prefer space inside or in a rear yard. Yard need not be fenced, but it should not be shared. It would be used for a garden and hanging clothes, with children playing in front on the walkway.

Bedrooms

Needs four bedrooms, would prefer five. Would take more small rooms than fewer large ones, felt two children to a room was good. Closets should be 6' in master bedroom with 3' per child.

Interview Format

The architect interviewer conducted each interview on an informal verbal basis, seeking answers to the questions below without forcing the situation into a question and answer format. Thus the desired information outline served as a structure against which the interviewer shaped the conversation, but not as the literal format of the interview.

Desired Information Outline

A. Kitchen Space
  1. Size
    a. How many people prepare a meal
    b. How many meals are cooked a day
    c. Do you have enough storage, what kind (pantry, wall, and base cab.)
    d. Would you like more cabinet space
    e. What size appliances would you like
    f. Would you like to do your wash in the kitchen if it were larger
    g. Do you use your table as a work space while preparing meals, or
    h. Would you rather work at a counter space
    i. Do you entertain your friends and guests in the kitchen
    j. How much time do you spend in the kitchen: a) a lot; b) quite a bit; c) as little as possible
  2. Location
    a. Would you like your kitchen at the front of the house so you could see the street while working in the kitchen, or would you like your kitchen to be at the rear of the house and open in to a small yard.
    b. Would you like your kitchen if it were open to the living room so you could see into the kitchen while sitting in the living room.
    c. Would you like your front door to open into your kitchen and eating area.

B. Eating Space
  1. Would you rather eat in the kitchen and alcove off the kitchen or a separate room.
  2. Would you object to the dining room being open to the living room.

C. Living Space
  1. What would you use the living room for: a) TV; b) entertaining friends; c) both
  2. Would you rather have a special room for watching television:
     a) 2 small rooms; b) 1 large room
  3. Where do the children play indoors: a) their bedrooms; b) the living room; c) around the kitchen/dining
  4. Where would you prefer them to play: a) special room near the kitchen where you can keep an eye on them; b) basement; c) an upstairs room
  5. How would you like a two-story house with bedrooms upstairs

D. Bedrooms
  1. Size and Number
     a) how many rooms would you need; b) would you rather have fewer large bedrooms or more small rooms
  2. How do you use your bedroom: a) sleep there only; b) sleep and watch TV; c) sleep and sewing room
  3. How much closet space would you need a) for yourself; b) for your children

E. Bathrooms
  1. Size and Number
  2. If you had a closet near the bathroom for linen and dirty clothes, would a small bath be okay

F. Outside Space
  1. If you had a small yard; a) would you like it in front or back; b) would you like fencing for privacy; c) would you use a shared yard; d) how often and for what use
  2. Would you like and use a front porch or prefer more space inside or more space in the rear yard
  3. Where would you like the car: a) In a lot; b) in front of the house
  4. Where would the kids play: a) backyard; b) front walk; c) go to playground

G. Storage Space
  1. Rather have a central storage or at your own house (giving up storage in house)
  2. Rather have storage at house in front or rear (would you give up rear yard space)
  3. Rather have basement storage

H. Community Facilities
  1. Would you rather use a central washing and drying facility or give up space in your house
  2. Would you use a community room: a) go to meetings; b) children indoor play space.

3. Do you prefer shared outdoor play equipment rather than your own.
4. What do you feel would be the most important use of community space: a) community building; b) play space c) extra parking

Limitations

We realize the limitations of interviewing such a small sample, but due to lack of time, and our inability to identify eligible families, it was not possible to expand the study to obtain results on other relevant issues. In an effort to reduce the scope of the survey, the questions were directed to obtain the maximum amount of information reqarding use and needs related to the kitchen, its adjacent living area and its immediate relation to the outside.

The difficulties of trying to obtain results relevant to an architect were compounded by the fact that few lay people can visualize space from abstract description. A small cardboard model was used in questioning people about location of space and size preference. A larger, more detailed model having more realistic furniture and finish materials would have been more effective in helping the individuals project themselves into the space.

A final limitation of this kind of survey, taken from a single ethnic population, in this case black, is that we can only find gross relationships and even these may not be able to be generalized to other cultural groups or situations. In addition, the survey doesn't reflect divergent needs within the group nor does it address open space or community development at all.

Despite the limitations the men conducting the survey had special experience due to our special interest as architects in the space that relates to how people live. Both authors had extensive prior experience dealing with ethnic groups and we both acknowledge that other groups have different values than our own. We believe that we, as architects, should accommodate the users point of view rather than our own, and believe we were able to differentiate our point of view from those surveyed.

Acknowledgements

Appreciation is noted for the cooperation of the New Haven Relocation Office which helped make this survey possible. Recognition is made of all the staff members of the Newhallville Project Office for their interest and encouragement. Particular thanks is extended to Robert Jackson, Project Director, and the survey team which included Harvey Ezekial, Project Planner, Bob Hopes, William Fisher and Mervyn Fernandes.

AN ORIGINAL OWNER INTERVIEW SURVEY OF FRANK LLOYD WRIGHT'S RESIDENTIAL ARCHITECTURE

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Introduction

Although he created an extraordinary range of architectural designs, Frank Lloyd Wright can be considered as primarily a residential architect. Approximately 70% of his total output of separate and distinct building designs were single-family residential. The percentage is even higher when one compares those designs actually built with unexecuted projects. Further, this ratio of residential to non-residential designs remained remarkably consistent throughout his professional career. The actual count is as follows:

Residential	653
Non-residential	276
Total	929

In addition, there were a considerable, but indeterminate, number of non-building designs such as graphics, murals, rug designs, furniture, etc. (1)

The Problem

Most members of the design profession are familiar with Wright's residential work as a considerable portion has been extensively published. However, not much is known about: (1) the interaction between Wright and his clients during the design phase, and (2) once built and occupied, how his houses "worked" as design solutions. (2)

It was the primary purpose of this study to obtain information concerning these two aspects of Wright's work by going directly to the persons most involved--the clients. A secondary, long-range, objective was that, hopefully, the data would provide a partial basis for the development of an evaluation framework (or scale) with which to measure the "quality" of a residential design.

Data on the owner survey is presented in this paper. Work is underway on the residential design evaluation framework, but not as yet completed. It will be reported in the future.

Method

During the planning phase of the study, two alternative methods of data collection were considered: Personal interviews with client-owners and the use of a mailout questionnaire. There were compelling advantages and disadvantages for each.

Logistical considerations seemed to preclude personal interviews. Wright-designed residences, particularly those of his later years where original owners were still available and could be queried, were widely scattered throughout the United States. On the other hand, the limitations of a standardized questionnaire format might not effectively elicit information on the sheer variety of Wright's designs, differences in site placement and use of materials.

The method chosen was in-depth personal interviews with original owners, primarily for the following two reasons:

1. It was anticipated that most, if not all, of the interviews would take place in the residence enabling the writer to obtain first hand knowledge of the building and direct his questions accordingly.
2. Copies of plans, correspondence with Wright and other materials were more likely to be available to verify ambiguous points.

It was recognized that the adoption of this method had one serious limitation--it would take a long time to obtain sufficient data on which to report. It did--a very long time.

It should be mentioned that this study was not sponsored or funded in the usual way. It was undertaken as an avocational pursuit. The writer's position as a behavioral scientist with a private firm involved substantial travel. Whenever it was known that a scheduled trip would place the writer in the vicinity of one of Wright's residences, a letter would be sent requesting an appointment for an interview. This arrangement worked reasonably well (although the concept of "vicinity" was frequently interpreted generously).

In order to maintain consistency throughout the survey, a set of 159 questions was developed and formed the basis for interviews with the client-owners. There were eight categories of questions:

	Number of Questions
Origin of commission: Why Wright?	11
Nature of owner's original requirements	23
Initial contact with Wright and extent of interaction during the planning phase	18
Construction/supervision experiences	16
How did the house "work"?	54
Maintenance practices and problems	17
Later modifications &/or additions	15
In retrospect: Owners' overall impressions	5
Total	159

The questions were intended to be open-end probes that would elicit the essential information in a roughly sequential and standardized manner and yet provide opportunities for the writer to interject specific questions and the owners to provide amplifying information as it occurred to them. (A copy of the questions used can be obtained by writing to the author.)

As the questions were developed to cover as wide an array of relevant points as possible, some were not applicable in specific instances. For example: Questions pertaining to snow loads, or the effects of freezing temperatures were omitted for residences in southern climates.

Because of the logistical difficulties involved in obtaining a random sample in the statistical sense, no attempt was made to do so. The writer feels the sample, if not statistically random, is representative by most criteria.

The sample consists of 33 original owners interviewed by the writer. A small number of brief reports concerning owners' comments on Wright's residential designs have been published since the data on this survey was obtained. These owner reports in part overlap, and in part are in addition to, the study sample. For the benefit of other investigators, the owners represented in these reports are included in the listing in Table I. Owners are listed alphabetically by State. A dot preceding the entry indicates it is one of the 33 owners interviewed in this study. The year is that in which the house was designed, followed by the owner's last name and the location of the residence. Numbers in parentheses refer to reference citations at the end of the report.

TABLE I.

California
. 1950 - Berger, San Anselmo
. 1948 - Buehler, Orinda
. 1923 - Freeman, Los Angeles
. 1936 - Hanna, Palo Alto (3)
. 1950 - Mathews, Atherton
. 1940 - Oboler, Malibu
. 1950 - Pearce, Bradbury

Illinois
. 1912 - Greene, Aurora (7)
1907 - Robie, Chicago (10, 15)

Iowa
. 1947 - Alsop, Oskaloosa (17)
. 1946 - Grant, Des Moines (17)
. 1946 - Walter, Quasqueton (17)
. 1957 - Trier, Des Moines

Michigan
. 1949 - Brown, Kalamazoo
. 1949 - McCartney, Kalamazoo
. 1948 - Meyer, Kalamazoo
. 1948 - Pratt, Kalamazoo

Minnesota
. 1947 - Bulbulian, Rochester (17)
. 1950 - Elam, Austin (17)
. 1950 - Keyes, Rochester (17)
. 1913 - Little, Lake Minnetonka
. 1952 - Lindholm, Cloquet
. 1955 - Loveness, Stillwater
. 1949 - Neils, Minneapolis (17)
1958 - Olfelt, St. Louis Park (17)

Nebraska
1905 - Sutton, McCook (9)

New York
1908 - Boynton, Rochester (7, 11)

Pennsylvania
. 1936 - Kaufmann, Bear Run (19)

South Carolina
. 1951 - Austin, Greenville
. 1939 - Stevens, Yemassee

Utah
. 1958 - Stromquist, Bountiful

Virginia
1939 - Pope, Falls Church (14)

Wisconsin
. 1946 - Adelman, Fox Point
. 1937 - Jacobs, Madison
. 1951 - Kinney, Lancaster
. 1938 - Manson, Wausau
. 1950 - Smith, Jefferson
. 1957 - Wright, Wausau

In addition to obtaining information from owners, a number of other sources were used in the study, primarily to verify ambiguous points;

1. Two visits to Taliesin, Wright's home in Wisconsin, were made to examine the files. A review of working drawings, particularly in those instances where alternate design schemes had been prepared, provided an opportunity to trace design modifications through their various stages.
2. Several discussions with John Howe, the head of the drafting office during Wright's later years, provided insight into the operation of Wright's studio.
3. At the time of the owner interviews it became possible to interview five of the building contractors involved. Questions concerning adequacy of working drawings, supervision, and construction costs were clarified.

Findings: General Comments

As a result of conducting this survey, the writer has learned to distrust the entire body of folklore that has grown up around Wright's architecture. Most, if not all, of it is just not true. For example:

- "Only wealthy clients could afford Wright." Actually, most of his clients were of quite modest means. There were scarcely ten really wealthy clients in his 65 years of residential practice.
- "Wright arrogantly dictates the design to his clients." The evidence is to the contrary. Wright invariably conducted all discussions with his clients personally and took considerable pains to ascertain the client's requirements and living habits. However, when Wright felt a client was ill informed in requesting a particular feature, he could be extraordinarily persuasive. He was also persuasive when he personally favored a particular design scheme for a given site.
- "Wright was lax in supervision of construction." Again, not true in the sense intended. The only reports of his early work are those of clients Angster (7), Boynton (7), Greene (7), and Robie (10), who pointedly indicate a remarkable attention to detail on Wright's part. In later years, when his residential practice was (literally) nationwide, the picture is less clear. Wright himself, as an elderly man (and an increasingly busy one), visited construction sites less frequently as the years went on. Field supervision was delegated to his senior staff apprentices who either periodically traveled to, or resided near, the site. Problems did arise, but were usually resolved without much delay. The Kaufmann house, "Fallingwater," is an example (19).
- "Wright's roofs leaked." A few (very few) did. There were other problems too, but probably no more than occur in the practice of any architectural firm doing innovative work.

Specific Findings

Space limitations in this paper do not permit reporting findings on each individual residence in the study. Instead, summary information is provided in the following numbered categories:

1. Type of Clientele
   Wright's residential clients, with very few exceptions, belonged to the upper-middle socio-economic level. A considerable percentage were salaried members of various professions such as college professors, high school teachers, librarians and research chemists. Others, non-salaried, were lawyers, doctors, and small businessmen, including several contractors and the owner of a gas station. Their educational level was probably higher than average. Typically, at least one member of the family had a strong interest in the arts. It is probably safe to say that they were somewhat more independent-minded than the average person.
2. Choice of Wright as Architect
   In most cases, the decision to approach Wright to be their architect was made by husband and wife jointly. It was usually the result of considerable study of publications on his work, and lengthy family discussions. Sometimes, a single member of the family (usually the wife) was the active force in the choice. There were two instances where college age children, upon learning their parents were planning to build, were instrumental in Wright's being selected. Occasionally, a client liked a particular published, but unexecuted, design and contacted Wright about having it built (the Walter house). One owner admitted to an initial acquisitive motive. "I wanted one of the old boy's masterpieces before he died. I figured it couldn't help but go up in value after his death--like an art work. But now that I have lived in it, I like

it and wouldn't sell it for anything."

3. Wright's Acceptance of the Commission
   Apparently, most clients approached Wright with some trepidation. "We really didn't think someone of his stature would bother with us" was a typically expressed feeling. In this sample, of course, all clients had been accepted, although many of them were so notified by mail after an initial face-to-face discussion. As an amusing aside, John Howe, the former head of Wright's drafting studio, reports that: "Wright developed a high regard for his clients simply because they were *his* clients. He found virtues in them which were indiscernible to others and almost refused to acknowledge their shortcomings."

4. Architect/Client Interaction
   After approaching Wright to be their architect, the clients were invited to visit Wright at one of the two Taliesins. Along with the invitation, they were provided with a brochure setting forth the fee arrangements: "Ten percent of the cost of the completed building which invariably includes the planting of the grounds and the major furnishings considered as part of the building scheme." They were requested to provide an accurate topographical survey of the property, as complete a list of requirements as possible, and cautioned that "Dwelling-houses upon urban lots will not be accepted. Acreage is indispensable." (The latter admonishment was apparently not always adhered to, as a number of the residences were found to be on suburban lots.)

   Almost all owners reported that, to their surprise, Wright proved to be remarkably easy to get along with in negotiations over the design. There were a number of instances where Wright either extensively modified a design or created one or more new schemes. In some cases where cost was a factor, Wright's staff dimensionally scaled down the design, while keeping the original concept intact.

5. Wright's Use of a Design Grid
   Wright consistently used a geometric grid (rectangles, triangles, diamonds, hexagonals, etc.) as a basis for developing his floor plan. Not always apparent was his use of a concomitant vertical unit system based upon masonry courses or boards and battens. This practice proved to be a mixed blessing for contractors. Laying out the grid was a precise and demanding task. However, once construction was underway, workmen were able to locate their finish work directly to lines on the floor slab and to vertical courses.

6. Typical Residential Configuration
   The residences in the sample followed Wright's usual "polliwog" configuration: The "body" being the living and social area (living room, dining area and kitchen) with the "tail" containing bedrooms and bath. Almost all of Wright's later residential designs are variations on this basic theme.

7. Construction/Superintendence
   The construction phase posed problems for almost all the owners. Sometimes the search for a sympathetic and competent contractor was difficult. Wright's foundation specifications and some of his roof support arrangements were considered dubious by authorities, delaying or denying the issuance of building permits. Mortgage sources were few and far between. Wright's organization helped where possible with advice on bids, or costs for special millwork. A senior staff apprentice was designated to superintend construction at the site.

8. Do-it-Yourself Instances
   The Berger, Grant and Loveness residences were built from the ground up by the owners. All three were well executed. The writer knows of two others which were partially owner-built (and look it). One in particular is atrociously executed.

   Another version of do-it-yourselfism developed among a group of Upjohn Institute chemists in Kalamazoo, Michigan. Seeking good housing at low cost, they formed a non-profit organization. They obtained the services of Wright to lay out the master site plan and design some of the houses, brought masonry and lumber by the trainload, and then helped each other over the rough spots of construction. Portions of the work on these houses was performed by contractors.

9. Siting
   Comments on the way the house was sited on the property were unanimously enthusiastic. Apparently, this was one area where Wright's talent was unequivocally demonstrated.

10. "Rock Ballast" Foundations
    Contractors reported that Wright's use of crushed rock instead of standard footings saved about 20% on foundation costs. No problems were reported, although some owners expressed concern over possible future difficulties with heating pipes beneath the slab.

11. Basements
    Wright did not favor basements and strongly

advised clients against them. Nevertheless, a few partial basements were included at client insistence.

12. Handling of Masonry
Wright used several masonry treatments which provided attractive visual effects, but were expensive. For red brick walls he specified red cement for all vertical joints and white cement for the horizontal joints. (This required the masons to use two mortar boards.) In cement block walls he favored setting every other course out (or in) one-half inch to create a shadow line. Again, a costly procedure, particularly where other work had to join to the masonry.

13. Fireplaces
Almost all owners report gratification with their fireplace(s), both as to location and function. There was a period in the late nineteen thirties, however, when Wright had a tendency to stretch the height of the fireplace opening to its functional limit. The fireplaces in the Willey, Johnson, and Manson houses are examples. Figure 1 shows the Manson fireplace in its original form. It smoked sufficiently to necessitate an inspection trip by Wright and several apprentices. Wright and company promptly reduced the height of the opening by adding several courses of brick.

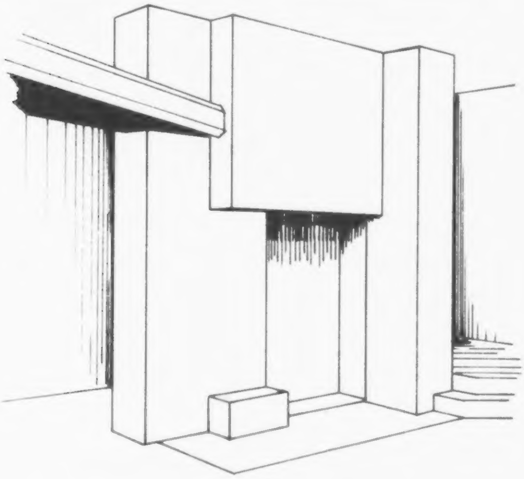

Figure 1. Fireplace in Manson House

14. Ventilation
Reyner Banham (5) has reported on the surprisingly advanced environmental control features in two of Wright's early works, the Robie and Baker houses. Wright has continued these same practices now somewhat modified, by creating a raised ceiling over the kitchen with clerestory windows for ventilation. Thus the kitchen space becomes the venting flue for the social portion of the house. As one owner remarked: "Best damn cocktail party house in the neighborhood. You open those vents and all the smoke drifts to the kitchen and disappears." Figure 2 illustrates a typical ventilation arrangement.

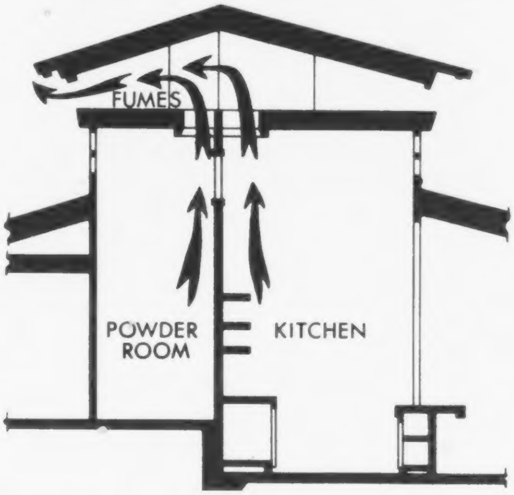

Figure 2. Cross-Section View of Hanna House

15. Heating
Wright's later houses were typically heated by hot water circulating in pipes beneath the slab. This furnished satisfactory heat in mild climates, and in northern areas as long as only throw rugs were used. However, when wall-to-wall carpeting was laid, as it was in several houses, substantial heat loss occurred. Eventually supplemental baseboard heating was added in these homes.

16. Kitchens
The largest bone of contention among clients' wives was the kitchen. The complaints were many and varied: "It's too small." I can't look out and watch the children." (Wright kitchens were usually centrally located, skylighted, and without windows.) "When I drop things on the concrete slab they break."

On the other hand, two design features were universally acclaimed: (1) Wright used a mix of open and closed shelves such that items in daily use were readily at hand while less frequently used items could be stored out of sight. (2) Wright very skillfully so positioned the kitchen in relation to the dining and living room areas that a housewife could make herself part of a social group or isolate herself by choosing a particular part of the kitchen in which to work.

17. Bathrooms
Wright "family" bathrooms were typically compact and usually located between a pair of bedrooms in the "tail" of the house. Occasionally a powder room would be ingeniously located just off the living room area and would elicit appreciative comment from guests.

18. Bedrooms
Like the bathrooms, the bedrooms were treated in utilitarian fashion and are probably the least "Wrightian" features in most of the residences, particularly those in the lower cost range. Even when space was restricted, however, Wright found ways to incorporate a small built-in writing table in a corner, or a reading alcove.

19. "Working" Hallways
In one form or another, each of the residences incorporated Wright's concept of using a hallway for several purposes. Typically a corridor would include a bank of storage cabinets or bookshelves along its entire length, sometimes broken up with a bench or shelf, and usually receiving light from a series of windows above the cabinets. Owners liked this feature for several reasons. It "organized" the storage and put it away from the social side of the house. It also added a touch of visual excitement to an otherwise utilitarian element.

20. Internal "Vistas"
One of the recognized features of a Wright residence is the presence of one or more visually delightful internal "vistas" equal to those looking toward outside views. A number of his larger residences were noted for these features (the Coonley and Johnson houses). Occasionally Wright was able to incorporate this feature in a smaller residence. Figure 3 shows the floor plan for a residence where a person in the living room can observe a fire burning in a bedroom fireplace at the end of a long hallway.

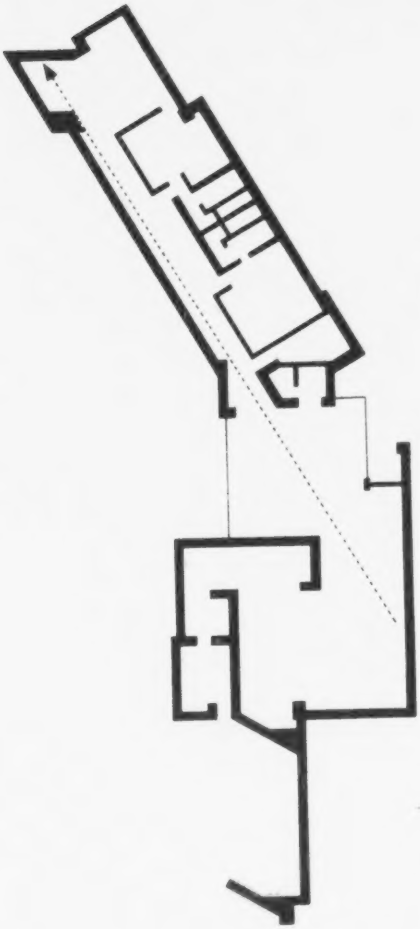

Figure 3. Long View Toward Bedroom Fireplace

21. Maintenance Considerations
Some of Wright's early residences have not held up well, particularly those with board and paster exteriors, and some extended cantilevers have shown deformation. In contrast, his later residences have required remarkably little maintenance, primarily due to the use of identical materials inside and out. Where possible, Wright specified integral coloring in his cement and plaster surfaces. Cracks are evident in plastered soffits in many instances where, according to clients, economy measures were employed during construction.

22. Modifications and/or Additions
Most residences in the sample remain substantially as designed and constructed. A few were planned for later expansion (the Berger, Brown, Hanna, and Kaufmann residences). The previously mentioned Berger residence was designed, at the client's request, as a three-stage do-it-yourself project. Figure 4 presents the floor plan showing the three successive stages in which it was to be built.

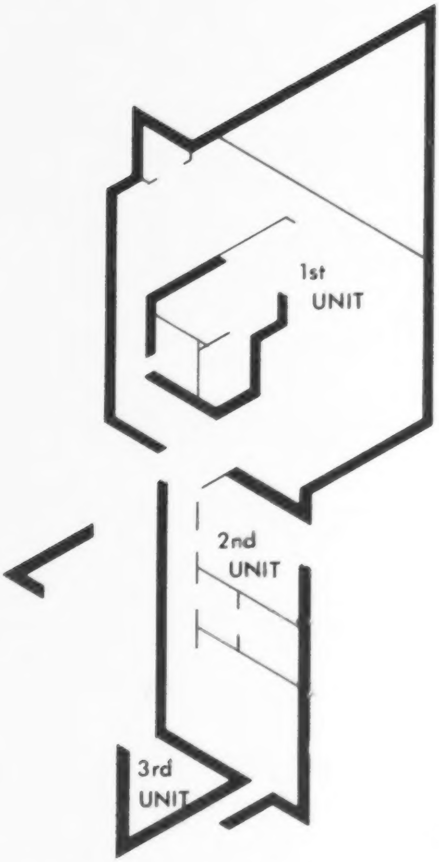

Figure 4. Three-Stage Building Plan for Berger House

Other owners (Oboler and Stevens) went back to Wright repeatedly for design alterations and additions due to changes in their family configurations. It was interesting to observe that most clients would think twice about altering any of Wright's work, while Wright himself apparently did not view it as all that sacred. When requested, he would cheerfully undertake anything from minor alterations to drastic residential surgery.

23. Non-Surviving Residences
It is worth noting that the Fuller residence designed in 1951 and located at Pass Christian, Mississippi was demolished by Hurricane Camille in 1969. Several others have been damaged by fire.

24. The Question of Cost
Were Wright's residences costly to build? A number of his houses were very large and very expensive (the Avery Coonely, Darwin Martin and Herbert Johnson houses). Several smaller houses could be considered expensive for their size (the Neils, Kaufmann and Walter houses). All three required complex construction techniques, and the latter two were built in remote areas. However, most of Wright's residences were probably no more expensive than comparable-sized dwellings of other custom designers. A few clients, willing to do some or all of the construction work, came through with remarkably low expense.

25. The Unexecuted Designs
A major question remains unanswered. Approximately 55% of Wright's residential designs were never built. The percentage is surprisingly high. Why? This study discovered a high level of owner satisfaction for built designs. Those clients who could not, or chose not to, build may present a different story and deserve a separate investigation.

Summary

If you are the original owner of a Frank Lloyd Wright house, you typically:

- Are in the upper middle socio-economic level.
- Are probably somewhat better educated (or at least more well read) than others in your level.
- Have a streak of independence in your makeup.
- Deliberated a long time before approaching Wright, and then with some trepidation.
- Were pleasantly surprised at how attentive and agreeable Wright was in preliminary discussions.
- Waited a considerable length of time for the preliminary sketches to arrive.
- If anything, waited even longer for the working drawings.
- Searched far afield for a contractor who was (1) willing, and (2) reasonable.
- Received a jolt when the construction bids began coming in.
- In some instances, returned to Wright to see what could be done to cut costs.
- Again, were pleasantly surprised to find Wright willing to modify the design (downward) and/or substitute other

materials (cheaper).

- Stood by observing, with pride, when the ground was broken.
- Stood by later, aghast, as workmen took frequent and unconscionably long periods of time to study the blueprints.
- Vowed, toward the end of construction, that you would never do it again.
- Moved in and spent the next year or two discovering a series of unexpected delights (and a few quirky features).
- Found your life somewhat altered, in subtle ways, ever since.
- Sooner or later found reasons to throw out some of the Wright-designed furniture.
- Eventually became resigned to dealing with a seemingly unending stream of visitors.

Notes and References

1. The count is the writer's and is based upon an examination of several extant lists of Wright's work, including the most recent "official" listing (unpublished) of the Frank Lloyd Wright Foundation. The figures are as accurate as diligent analysis permits, but still somewhat approximate. Records are spotty for the early years, and occasional puzzling duplications exist which present difficulties in interpretation.
2. A point worth mentioning is that the actual impetus for the study resulted from a weekend visit to Wright's home in Wisconsin in 1956, when Wright was still alive. The writer, observing a 2-hour design critique by Wright of his students' work, was struck by the fact that Wright's entire critique was based upon user considerations rather than the usual (and expected) emphasis upon form, proportion, scale, or other visual elements. At that time, the writer began to speculate about what the actual users of Wright's houses might report.
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14: WORK ENVIRONMENTS

CHANGES IN EMPLOYEE ATTITUDES AND WORK PRACTICES IN AN OFFICE LANDSCAPE

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Abstract

A field study was made of the attitudes and perceptions of 120 employees towards work practices and their office environment. The subjects' responses were recorded on a semantic scaling instrument immediately before, and nine months after, a change in their surroundings from a conventional mixture of open plan, semi-private, and private offices, to a landscaped design. Statistical analyses of scores showed that while the subjects rated the landscaped design significantly higher in aesthetic value, it was perceived as significantly less utilitarian and efficient a place in which to work. An increase in noise level and number of visual distractions, and a loss of privacy were chief causes of complaint about the landscaped offices. There was no evidence showing an increase in productivity concomitant with installation of an office landscape.

Preface

"At present, design decisions affecting the social environment of office buildings are made almost entirely on the basis of expectation or personal prejudice, rather than knowledge" (1). The Pilkington Research Unit said this in 1966, and whereas it is still true today, there is a growing awareness among the architectural and design professions of a need to create a rational basis for design. But as Harries (2), and Kaplan and Brookes (3) have discussed, architects and designers rarely engage, or are involved, in the processes of test and evaluation, even though such procedures are obviously necessary if design errors of omission and comission are to be corrected through modification of experience.

Nevertheless, in recent years there have been increasing numbers of studies published on the influence of the physical environment on human behavior, as Wools and Canter (3), and Taylor (4), among others, have indicated. In particular, attention has been directed to organizational behavior within the office environment, which subject is the focus of the following paper.

Introduction

"The office landscape is an innovative concept in office design first conceived by Eberhard and Wolfgang Schnelle, West German furniture manufacturers, and now being promoted in the United States by the Quickborner Team, organizational consultants. The innovators have worked out a rationale (6) for how the physical environment of an office landscape affects a variety of organizational processes. They claim for office landscape a number of significant advantages relative to a conventional office [Bach (7), Progressive Architecture (8)]" (9).

Claims have been made of both tangible and intangible improvements by applying the concepts of open landscape within the office. The tangible claims which have been reported by observers of European installations (10) are:

- 40-50% reduction in space requirements;
- 20% decrease in maintenance costs;
- 95% reduction in set-up and renovation times.

The intangible, or more exactly, less tangible claims for the landscaped office are said to be:

- 10-20% increase in staff productivity;
- improved staff morale and decreased absenteeism.

Altogether these make a potentially valuable batch of positive attributes, particularly for companies with hundreds of office based employees, and it is little wonder, therefore, that at lease a score(11) of U.S. corporations have installed landscape operations. The more prudent of these corporations have set up test installations in an attempt to measure the effects of the new surroundings on the occupants. The rumours about outstanding improvements in performance which appear occasionally in the popular press (for example, 12), serve only to add fuel to the fire of speculation.

In fact, of the three most noted office landscape test installations in the U.S., i.e. Eastman Kodak at Rochester, DuPont Freon Division at Wilmington, and Port of New York Authority, only the latter has released a thorough and comprehensive test report detailing in full the results of a before and after study (13). Neither of the former two companies has formally released full data on the efficacy of their landscaped test installations (14).

In a one page summary of a resurvey of Kodak employees, it is reported that the "most liked quality of landscaping according to the employees surveyed was the improved psychological climate -- such things as color, attractiveness, and atmosphere. The most frequent criticism was that the landscape was too public. This response increased from 21 per cent to 34 per cent after one year. Other complaints cited concerned temperature control and specific equipment and storage facilities" (15). Other than an increased concern for lack of privacy the overall reaction to the office landscape was favorable, it is said.

This summary also refers to an increase in employees' beliefs that they were communicating more effectively and making better contact with their fellow workers, though it is not made clear whether this is due to procedural or organizational practices which could have been made without any environmental changes.

The comprehensive Port Authority Study "failed to reveal advantages inherent in the office landscape concept, as implemented in the test installation, which could not have been obtained by providing an equivalent physical design environment in a conventional office of good design. The efficiencies reputed to come with the office landscape concept result from a concurr ent redesign in the work activities and the communication pattern and the provision of a layout to conform to the new activities" (16).

Zeitlin was concerned solely with the motivational aspects of design and not with office economics. He continues that "the significant motivational asset that the office landscape concept possesses, that of the development of small, closely knit, functional work groups who perceive themselves as united in task and striving for a common goal has all but been ignored in most discussions of the subject. The results of thisstudy point up this fact most clearly. Despite extreme change in physical environment, from a very bad conventional office, to a rather good landscaped office, attitudinal changes about the work itself, the nature of the job and the role of the individual with respect to his job changed only minimally. It is clear that the physical design of the office, whether landscaped or not, cannot instill motivation within its workforce."

This conclusion goes directly against the claims of the landscape protagonists. A further study (17) of office landscape tends to support Zeitlin's findings. Hundert and Greenfield found that noise and bustle had increased in the landscaped over the conventional design, privacy had decreased, and distractions generally increased. At the same time interpersonel relationships had perhaps increased slightly, though cooperation and team spirit had decreased, but inter-group cooperation remained unchanged.

They concluded that the office is far more complex an entity than is allowed for in the basic office landscape assumptions, and that their findings raised some questions about the utility of this form of layout.

In order to resolve some of these conflicting reports and rumours the following study was conducted.

Method

Three departments in a major United States retailing firm participated in the research. These departments, part of corporate headquarters operations, consisted of 120 persons ranging in occupation from filing clerk through clerical, secretarial grades and supervisors to senior management, including one vice president. There was a roughly 50/50 mix of males and females, with the women acting as secretaries and generally in the lower grade occupations, with one or two exceptions. The departments handled different types of work although their tasks involved one another: one was involved with purchasing and so had frequent contact with outside visitors, the second dealt with servicing inquiries from nationwide retail outlets and was responsible for reordering and maintaining all parts lists and similar records. The smallest department, 12 persons, was concerned with building management and administration, and thus was actively involved emotionally in this study.

At the outset of the study, the staff was occupying about 30,000 sq. ft. of office space, mainly open plan rectilinear, with section heads occupying semi-private offices partitioned off against the outside walls. The three department heads, vice president and one or two other senior managers occupied private offices. The existing space layout was clearly inconvenient from the point of view of ease of supervision and inter group communication due to a recent expansion of services. Congestion in some areas, fairly inadequate facilities for some, and a general need to reorganize were the motivations for considering a new style of office

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design - office landscape.

The object of the study was to determine whether a change in office surroundings could affect productivity, group cohesion and interaction, morale, turnover, etc., and to determine whether a notoriously conservative type of employee would tolerate a change in style of office operations - less status differential, more persons in open areas.

Because the project was under the control of building management, rather than operations or personnel, it was not possible to set up personality metrics of, say, dogmatism [such as has been used by Landis (18) with interesting results], nor to introduce or develop metrics of office productivity. In addition, for the 'before' and 'after' conditions of the experiment there was to be no change in office procedures: all tasks were to be the same in both environmental conditions.

An instrument was developed to establish a metric which would meet experimental goals within these procedural restrictions. A questionnaire consisting of a series of 45 semantic scales was administered to the employees. The semantic descriptors had been previously developed for another study (19). A modified Stapel Scale was used to define the semantic continuum, rather than bi-polar descriptors as preferred by Osgood (20), it being arguable whether Osgood's evaluative-type scales represent a linear continuum, or whether the continuum breaks for another dimension at the neutral, center or zero point of the scale (21).

In addition to semantic scaling, subjects were asked to write down the three things they disliked most about the office environment, and the three things they liked most.

Procedure

The subjects were asked to respond to the same scales three times in answer to three different instructions: first, to describe their present office workspace; second, to describe their ideal office workspace; and third, to describe the way their co-workers want their office workspace to be. The questionnaire was administered, by groups, immediately before announcing plans to move to a new space, and nine months after move in to the redesigned space.

Despite attempts to control the situation before first administration of the questionnaire, rumours of changes in office plans had circulated among the staff, and all were eagerly awaiting a formal presentation of plans. None were aware that an attempt to establish metrics of attitude and performance was to be made.

Shortly after the announcement all personnel were interviewed and the three departments were moved into uncomfortable temporary quarters in another part of the city while their old office interiors were demolished and rennovated in a modern landscape mode. New furniture, fittings and fixtures were provided. Workspace needs and equipment facilities were based on, virtually, a one for one translation of old furniture for new, except in the occasional instances where obvious shortages of flat-top work space or storage units existed. Concommitant with rennovation, carpeting was substituted for vinyl tiling, design and decor altered, etc.

Objective records of noise levels were made in the old and new offices, together with observations of illumination levels provided at work surfaces.

Results

Responses to the semantic scale were scored from zero, indicating least association between descriptor and scale with perception as defined by the set, to 4 representing the most association of word scale with perception. The scale mean score, on a basis of chance, is 2.00. Despite the apparent cardinality of the number process it is not acceptable to infer a cardinal progression of intensity in the underlying human dynamics [as discussed, for example, in (22) and (23)].

About 100 completed questionnaires were accepted for coding and scoring. Although half a dozen subjects refused to participate in the study, most rejections of questionnaires are accounted for by the fact that they were mainly incomplete or incorrectly filled out.

Factor analyses were conducted of the subject's responses to the 45 descriptors. It is a practice to collapse the matrix of semantic space along dimensions of n subjects (for group data) and along the dimensions of replication for time and/or set, following Osgood's suggested practice (24). It is clearly incorrect, however, to use within one analysis a replication of concepts of space (set) otherwise the factor matrix will be forced to yield inordinately high factor scores.

For this study the scores for each scale were correlated with every other scale, and the factor loadings produced from analysis of the correlation matrix were rotated to a varimax solution (25). This procedure was undertaken for each set for each experimental condition and the resulting factor loadings examined for continuity.

By and large there was agreement of factors between conditions, although the order of occurrence of the factors tended to vary slightly (the amount of common variance accounted for by each). The 13 factors which recurred accounted for approximately 60 per cent of the common variance.

The results presented here have been grouped according to these factor loadings, and descriptive phrases assigned to them by the author. Chi-square tests were applied to the several hundred ways in which the sets of data can be combined for the recorded characteristic differences of group, sex, time of response (before or after), perceptu al set (existing, ideal or others), and those in private and semi private offices or originally in open space.

Whereas idiosyncratic variations between subset categories were observed , space precludes giving more than a glimpse of the full results, and here are presented the mean scores for all subjects considered as a homogeneous group, Table 1. (see over)

Table 2 (see over) shows the responses to the open ended question concerning likes and dislikes within the office environment.

Measures of Reliability and Validity

The measure of reliability of the semantic scale is indicated by the coincidence of columns E2 under the two experimental conditions. In E2 the subjects are describing the "ideal" office environment. Clearly their perceptions have not shifted over a one year period, despite dramatic changes in their surroundings. Statistical calculations of the comparison of these two scales (not reported here) show an extremely high degree of correlation.

Regarding validity of the semantic metric, the degree of predictive validity for this form of scale has been demonstrated elsewhere (26). No attempts have been made to determine the construct validity of the scales used here due to the nature of the initial experimental limits.

Discussion

The answers to two questions "Is the new landscaped office better than the old conventional one?" and "Does the new design fulfill the needs and expectations?" can be answered directly from comparison of columns E1 in both the before and after situation, and columns E1 in the after situation with E2 in the first, (respectively).

In item groups 1, which appear to be related to Function and Economy of design, the old conventional office is seen as more functional and economical (c.f. column E1) (significance at 0.02).

In item 2 (Group Cohesiveness, Sociability and Values) the scores on scales "aggresive" and "independent" are not significantly different. The landscaped office is seen as a more sociable place in which to work, and is judged as less conventional, more progressive, than before.

From the point of view of security, item 3, the landscaped design is perceived as least secure.

Layout and organization items consisting of scales calm, noisy, quiet and spacious as one factor, and open and private as a second, show the landscape office to be as crowded, noisy and bustling as before (not significantly different), and the openness and lack of privacy are perceived as dramatically increased.

Responses to "dark" and "light" scale may apply to the Physical Environment rather than mood, and although objective measures of illumination at the work surface showed there to be a general increase, this was not significantly perceived as such.

It is in Aesthetics that the new landscape design scored heavily over the old. Much less cold, hard, less hostile, very much more colorful and contrasting. It was to be hoped that a relationship could be found between the Aesthetics and the Geometrics of the situations, which would have been useful to future office designers. However the Geometric items were factored out in separate dimensions as shown. Less rectangularity and more roundness of the new landscaped design was to be predicted due to the change in style of furniture, amongst other things.

By recording a description of the "ideal" environment during the first test administration, it should have been possible to observe the areas of design which were of most concern to the occupants. Presumably the aim of design would be to correct

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or minimize discrepancies of design between what existed and what was felt to be needed, and thereby provide the most satisfactory environment. Why this was not attempted is outside the scope of this paper.

Comparison of columns E2, Conventional, and E1, Landscaped, Table 1, show that only in a few of the second items (Aesthetics and Geometrics) have original desires started to approach the "ideal". It is doubtful, of course, that close correlation would ever be achieved, for satisfaction in one manner may merely stimulate an increase in appetite for more. However, in this case the evidence presented here leads to the suspicion that the landscaped design may not be as effective a workplace as it has been promoted to be.

It is reported to be far too open, not private enough, too noisy and distracting, and nowhere near secure enough. Oddly enough, the landscaped design appears to have undershot the mark in being not progressive enough, though it is starting to be characterized as a satisfactorily cheerful, leisurely, relaxing and sociable place.

Because no attempts were made to change work practices and procedures, the new design rates as poorly as the old. This is to be expected because, despite the claims of landscape protagonists, business on hand must clearly determine the ways of working, and the environment is by and large an adjunct of procedure - it provides light, seat, flat surface. There is no reason why a change of, in effect, aesthetics as in this study, Zeitlin's and Hundert's, should impinge upon work efficiency. If anything, in this case, work output went down, though the degree is arguable and its causes non determinable.

A great cause for concern appears to be the degree of privacy and noise control afforded to the occupants of the landscaped office. The Kodak Summary (27), Zeitlin, and Hundert, all seem to concur on this point, and in other areas of habitability, (28), (29) and (30) for example, these same elements of design are stressed as being of extreme improtance. The proponents of office landscape suggest that occupant's can turn their backs to avoid distractions but in actuality this either does not happen or the effect is still sensed as being present.

The results reported in Table 2 tend to confirm this. Whether this is a function of just the particular case of of the general situation is not confirmed by the few studies so far reported, but a trend appears to be forming. Noise of conversations and lack of privacy head the list of main causes for discontent in the landscaped office. Whereas conversations were very noticeable in the old environment, now privacy has become a cause of concern, tending to confirm the results of the semantic scaling.

Again offering a notion of validity for the semantic scaling, the occupants report the introduction of colors, comfortable furniture and attractive decor as positive attributes of the landscaped office.

Conclusions

The landscaped office used in this study did not fulfill the expectation of increased efficiency. At no level of employee task from manger to clerical worker, were there indications of improvements; if anything, it was slightly worse. Not that this can be construed as a function of all office landscapes, but in this instance efficiency appeared to fall far short of what the staff believed could have been achieved. Presumably, both work organization and landscape should be changed and evolved simultaneously.

Group cohesiveness appears to have been improved slightly, and this may be a function of closer group identity, where groups were more separated in the conventional design. Perhaps this would have been achieved using a modern but conventional redesign, and this may also be true of the decor which rated very highly in the office landscape.

Noise and lack of privacy were destinct causes for concern in the test installation, and though the former may be controllable it is difficult to see how an impression of privacy suggested through subtle architectural interior design can be substituted for a deep rooted belief in the safety behind a closed door.

In some respects the landscape concept would appear to have been unable closely to reflect in two dimensions the rich, multi-dimensional functional and social interactions which occur within an office.

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Table 1. Mean scores for all subjects responding to the semantic scaling of perceptions of the environment. E1, E2, E3 refer to the instructional set to scale: first perceptions of the "existing workplace" (E1), next the "ideal workplace" (E2), and "other people's ideal workplace" (E3).

			Conventional Office (before)			Landscaped Office (after)		
Item		Scale	E1	E2	E3	E1	E2	E3
1	Function/Economy	efficient	*2.23	3.64	3.44	*1.80	3.51	3.27
		meaningful	*2.07	3.36	3.18	*1.92	3.11	3.05
		methodical	*2.08	2.60	2.43	*1.60	2.29	2.31
		orderly	*2.08	3.40	3.14	*1.68	3.21	2.98
		adaptable	*1.79	3.28	3.07	*2.04	3.18	3.04
		economical	*2.25	2.69	2.48	*1.69	2.43	2.30
		utilitarian	*1.76	2.26	2.12	*1.47	2.40	2.35
		aggressive	1.66	2.49	2.24	*1.45	2.13	2.02
		independent	1.88	2.50	2.42	*1.49	2.29	2.17
2	Cohesiveness/Sociability	cheerful	*1.92	3.48	3.41	*2.45	3.33	3.28
		leisurely	*1.18	2.09	2.44	*1.69	2.10	2.47
		relaxing	*1.27	2.54	2.62	*1.56	2.58	2.67
		sociable	*2.02	2.46	2.69	*2.32	2.48	2.68
		conventional	*2.42	1.97	2.10	*1.09	1.95	2.08
		conservative	*2.39	1.76	1.87	*1.01	1.88	1.95
		progressive	*1.81	3.29	3.05	*2.35	2.99	2.80
		reserved	*1.81	2.28	2.22	*1.23	2.14	2.18
		serious	*2.36	2.45	2.24	*1.63	2.38	2.27
3	Security	reliable	*2.17	3.26	3.18	*1.68	3.08	2.95
		secure	*1.81	3.01	2.99	*1.33	2.84	2.83
		stable	*2.17	2.76	2.73	*1.43	2.64	2.61
4	Organisation	calm	1.53	2.96	2.93	*1.64	2.86	2.31
		noisy	2.43	0.42	0.51	*2.65	0.41	0.36
		quiet	1.04	2.98	2.89	*1.02	2.96	3.07
		spacious	1.02	2.94	3.05	*0.93	2.90	3.18

continued over

Table 1 (continued)

Item		Scale	Conventional Office (before) E1	Conventional Office (before) E2	Conventional Office (before) E3	Landscaped Office (after) E1	Landscaped Office (after) E2	Landscaped Office (after) E3
4	Layout/	open	* 2.07	1.88	1.77	* 2.77	1.72	1.43
		private	* 1.12	2.74	2.76	* 0.71	2.94	2.97
5	Physical	dark	0.50	0.30	0.33	* 0.64	0.34	0.32
		light	2.74	3.16	3.17	* 2.61	3.20	3.21
		warm	* 1.68	2.82	2.78	* 2.10	2.94	2.95
6	Aesthetics	cold	* 1.33	0.39	0.38	* 0.76	0.46	0.40
		hard	* 1.56	0.35	0.31	* 0.92	0.26	0.35
		hostile	* 0.84	0.21	0.20	* 0.74	0.21	0.18
		colorful	* 1.14	2.93	2.86	2.65	2.96	2.93
		contrasting	* 1.08	2.34	2.40	2.17	2.31	2.29
7	Geometrics	curved	* 0.38	1.57	1.45	1.36	1.42	1.23
		rounded	* 0.50	1.58	1.34	* 1.11	1.52	1.38
		angular	1.93	1.61	1.62	* 1.77	1.51	1.45
		triangular	* 0.37	0.77	0.78	0.99	0.86	0.82
		rectangular	* 2.36	1.48	1.52	1.41	1.38	1.58
		square	* 2.12	1.20	1.30	1.44	1.18	1.34

Conventional Office (before): n = 98
*significant difference between E1 (before) and E1 (after), $p < .02$

Landscaped Office (after): n = 96
*significant difference between E1 (after) and E2 (before), $p < .02$

Table 2. Responses to the open ended question asking subjects to list three major 'dislikes' and three major 'likes' with their existing office environment. The categories are arranged in rank order according to the number of times each was listed.

Conventional Office (before)

Dislikes
crowding of desks 47
noise of conversations 43
poor adjacencies and layout 37
poor HVAC 31
poor lighting and glare 24
drab decor 21
inadequate workspace storage/shelving 20
inadequate filing spaces 20
lack of privacy 18
lack of provision for visitors 13
no windows 8
in traffic flow 8
lack of machines and business equipment 8
need for coat racks 5
lack of flexibility in arrangement of space 3
lack of room for expansion 1

Likes
good lighting 37
good adjacencies and layout 34
good furniture and equipment 27
adequate privacy 27
sufficient room 16
location in building 11
pleasant co-workers 11
cleanliness of workspace 7
decor 7
close to canteen 7 (see above: location in building)
adequate HVAC 6
efficient atmosphere 4
quiet 2
other people's offices 2
impression made on visitors
good pin-up space

continued over

Table 2 (continued)

Landscaped Office (after)

Dislikes
noise of conversations 47
lack of privacy 42
crowding of desks 43
flat top desk too small 26
lack of drawer space for personal storage 24
adjacencies and layout 24
poor HVAC 17
lack of shelf space 16
poor lighting 8
too many plants and insects 7
cheapness of furniture construction 7
lack of filing space 7
drab decor 6
in traffic flow 5
uncomfortable chairs 4
lack of electrical outlet 3
getting lost 2
no windows 2
no provision for visitors 2
poor phone location at desk 2
poor expression of status 1
no buzzer on phone 1

Likes
colorful design 34
comfortable chairs/furniture/workplace 34
attractive decor 26
indoor plants 18
good lighting 18
cheerful atmosphere 13
a carpet of floor 13
lack of noise 12
adequate adjacencies and layout 11
modern appearance 10
adaptability of furniture 7
adequate privacy 6
small conference areas/provision for visitors 5
ease of keeping workplace clean and tidy 4
better filing space 4
more personal contact 4
good impression on visitors 3
out of traffic flow 2
easy to supervise secretar

USING INTERVIEWS OF PRESENT OFFICE WORKERS IN PLANNING NEW OFFICES

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1. Abstract

216 employees of the Provincial Government of British Columbia were interviewed in their homes on attitudes, behavior, and perceived needs, related to their present office environment, including physical facilities, social and functional context, and image. Findings were used in providing programmatic guidance to the architects for a new provincial office building.

2. Contents

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3. Context and Objectives of the Study

On a two-block site in downtown Vancouver, B.C., the Provincial Government is building new Law Courts, government offices and related facilities. Most of the offices will be housed in a 55-story office building, planned for approximately 4,000 workers at full occupancy.

The project, known as "The British Columbia Building", is being built under the control and direction of the Department of Public Works of the Province. The architects are a joint venture working under the name of MN+TBP, with C.E. Pratt, R.S. Nairne, R.J. Thom, P.M. Merrick and J.B. Macdonald as principals. Formal planning work started in 1969, and construction will commence during the winter of 1971-72.

TEAG - The Environmental Analysis Group was appointed program consultants for the project in March, 1970. They report directly to the Department of Public Works, and consult with the architects, who are Prime Consultants. TEAG has prepared a general Design Program for the project in sufficient detail to permit building design by the architects. The detailed investigations and programming to permit layout of the typical office floors, locating work-groups and individuals, will be done as the building approaches occupancy. The study discussed in this paper was conducted by TEAG as part of its normal professional work on the project.

Our objective was to provide the architects and the client (the Provincial Government) with programmatic guidance derived from an investigation of the perceived needs, attitudes, and behavior of the people who would be working in the new offices. This would supplement the program data about activities, numbers of people and equipment, proximity relationships, special floor loads and mechanical engineering requirements, areas required, etc., that could be developed from straightforward interviews, observations, and systematic analysis.

Our client, the Department of Public Works of the Province of British Columbia, was particularly concerned that the new building should meet not only the functional needs of the organizational units occupying it, but also that it should satisfy the needs of the working staff, and of the visiting public, for a humane and supportive environment.

We planned this survey research study as part of our programming work for matters of general building character and form, of mood and image, and of how the building should be perceived by its users. We also hoped to develop some specific facts that would be used in programming certain of the facilities in the building complex, as to anticipated need and use, and for relative importance to the future occupants of the building.

We decided to investigate the following six subject areas:

a. Employee attitudes and impressions toward their work situation -- its physical, social and psychological factors.

b. Employees' actual behavior in the work situation; their uses of services; their use of transportation; their relationships with peers/colleagues in the work hierarchy.

c. Employees' awareness and attitudes toward the new government building and about a possible move they might make.

d. Factors related to the needs of employees in current and future work situations.

e. Profile of employees in relation to differing attitudes about current and future work situations.

f. Image factors -- both physical and social -- that employees feel are necessary for a satisfactory working environment.

The study was to be reported both to the architects and to the Government. It was to result in recommendations that would be as specific, pragmatic and as directly usable as possible.

The need for strict economy of funds, and, despite unavoidable interruptions, the need for results at the earliest possible date, prevented us from using certain research methods that under other circumstances would have given added depth and authority to our findings. The choice of methods is discussed later.

4. Methods and Experiences

a. Prior Survey Research Experience

TEAG had considerable prior experience in using survey research for the programming of buildings and larger environments.(1) In particular, Gerald Davis and Dr. Armond Fields had worked extensively with interview and observational methods in ways that were directly related to the current project.

Most recently, as part of this same project, they had conducted a survey of visitors to the present offices of the government organizations that would be housed in the new British Columbia Building.(2) In this study they had also interviewed in Vancouver a control sample of visitors to office buildings which did not house government employees.

b. Selection of Method

We chose individual interviews as our principal source of data, because we wanted to probe in depth with a carefully controlled sample of respondents. We interviewed in the home because we did not want our responses to be biased by the presence or proximity of superiors or fellow workers, and because for at least part of the interview we did not want the purposes of the interview to be realized by the respondent. (We apparently succeeded in this latter objective except where one supervisor announced the interviews to his staff. We were able to identify and isolate this group of respondents. Their responses did not vary significantly from the overall patterns.) We would have preferred to include substantial additional planned observation specifically for this study, but because of time and budget limitations, we did only modest informal observation at the time of preparing the questionnaire, and during analysis, to supplement what we already knew about the groups from which the respondents were drawn, and their work-places. Prior to this study, members of the TEAG staff had already interviewed and observed at every location at which respondents worked.

c. Development and Design of the Questionnaire

The TEAG team on the project, during a number of working sessions, developed a listing of the kinds of information they expected would be needed by the architects, and could be obtained through behavioral research. It was recognized that the architects would probably not use the data directly, but rather would work from statements of architectural criteria that had been developed by TEAG, based on the data. Therefore, the kinds of information listed were intended for evaluation and interpretation by the programmers, rather than for direct translation into design by the architects. Out of the listing and related notes, a draft of the questionnaire was developed and subsequently refined.

The interview contained four methods of questioning. First, there were short answer questions dealing with employees' actual behavior and use patterns, i.e. "first of all, how do you get to work?" Second, there were depth probes, open-ended questions which allowed a respondent to freely discuss the questions that were asked, i.e., "What are the specific things you like about the place you work?" Third, there were image projection questions, in which respondents would select out of a list of words or phrases those that were meaningful to them, i.e.,

> Here is a list of different characteristics that describe buildings in which you might work. I'd like you to tell me to what degree each of these characteristics should be a part of such a building.
>
> Secure
> Have friendly people
> Larger size
> More men
> etc.

Fourth, there were a series of questions that were designed to obtain information about the personalities of employees, basic factors that could be related to reported behavior patterns and images. The interview closed with a series of demographic questions.

Typical interviews lasted about one and a half hours. Some lasted up to two hours.

d. Sample and Field Work

The universe from which all respondents were selected consisted of those organizations now located in the Vancouver area which would be occupying office space in the new building. The government provided us with lists of employees, including home addresses. Out of these lists, random selections were made of potential respondents. A large enough list was developed to take into account losses due to refusals, illness, etc. A control sample was drawn from employees of private tenants of commercial buildings in Vancouver.

For the most part, respondents were contacted at home and interviewed at the initial contact. In some cases, appointments were made with respondents for interviewing at a later date. Only 10% of the people contacted refused to cooperate for the interview.

All interviews were conducted on a face-to-face basis in the homes of the respondents. Interviewers were drawn from the permanent staff of Regional Marketing Surveys, Ltd., of Vancouver. They were controlled and supervised by TEAG research personnel during the field work.

Out of the total of 216 interviews, 111 were with males and 105 with females. Of the total, 46 were conducted with people at executive levels and 170 with people at the secretarial, clerical and technical levels.

e. Analysis

After the questionnaire forms had been "cleaned" and validated, they were read in their entirety by the analysts and coded for tabulation. The coding was validated on a sample of the questionnaires.

The data was tabulated by computer, with responses to all questions being reported under the following headings:

(1) Total sample.

(2) Sex.

(3) Work attitude as established by responses within the questionnaire: positive; neutral, negative.

(4) Age category.

(5) Job title: executive; secretary/clerical/technical.

(6) Organizational grouping: specific government organization, by organization; control sample from private tenants.

The documentary report was prepared in two parts. The first, with summary tables, contained the following sections:

- Who are the people? Demographic and personality profile of employees. Their relationship to visitors.

- Impressions and attitudes about the work situation. Attitudes about the work situation. Coffee breaks. Outside areas. Problem areas.

- People-to-people interactions in the work situation. Who, where, how. Frequency. Physical proximity.

- Use and attitudes about facilities and services. Use. Location. Frequency. Dollars spent. Likes and dislikes.

- Use and attitudes toward transportation.

- Recall and attitudes about the new government building. Desires, needs in the new building.

The second part contained recommendations for architectural design and for management:

- Perception of the environment. Massing and exterior form. Interior spaces, general and for work areas, and for non-work areas.

- People relating to people. Architectural aspects. Management aspects.

- Functional requirements. Heating and ventilating. Noise. Food service. Commercial service. Transportation to and from work.

- Management and operations.

f. Presentation of results

The findings were presented verbally to the executives of the Department of Public Works, representing the Provincial Government, and then separately to the architects. At both presentations there was lengthy discussion and questioning. At the end of the meetings a detailed formal report document was provided.(3) Thereafter, in the course of working sessions with the architects, the TEAG team explained and elaborated on various aspects of the report, as requested.

g. Individual participation.

The study was directed by Gerald Davis, who is also director of the overall project for TEAG. Dr. Armond Fields was principally responsible for the design of the questionnaire, and the tabulating system. He coded the open-ended questions, and then wrote the first part of the analysis, including the selection and design of the summary tables. Gerald Davis wrote the second part of the analysis, and worked with the architects thereafter. Graham Brawn assisted both Dr. Fields and Mr. Davis in the structuring of the data for analysis and reporting. Other members of the TEAG staff participated in determination of the subject areas to be covered, the organization and processing of the field work, and the coding of the questionnaires.

5. Selected Findings

Part One of the findings contained summaries of the responses to questions and the direct interpretations of those responses. Part Two contained recommendations for architectural design and for management, based on the findings reported in Part One. The following section contains selections from the two parts.

Part One

a. Who are the People?

The demographic data that we obtained from our sample was consistent with government data. 58% of employees in both executive and secretarial/clerical/technical categories had lived in Vancouver over 15 years. 39% of the employees had been working at their current jobs for 10 years or more. Only 1/4 of the employees had been at their jobs two years or less. Among the typical personality characteristics were "traditional" patterns of life style. Based on their responses, employees enjoy family-shared experiences and adhere to family ethics in their ways of life. They generally liked meeting people and liked having new experiences; they are social, interacting and outgoing.

In many ways the employees we interviewed were similar to the visitors to Vancouver office buildings we had interviewed in an earlier study on the same project. The two groups had similar age profiles, similar education levels, and had lived in Vancouver roughly equivalent lengths of time. Both groups did not feel bothered by the people that they deal with, but were concerned about specific things with which they worked, or used.

In reporting office behavior, it appeared that employees are friendly and outgoing, and communicate well with others. There was suggested a sense of closeness among employees. It was the things that create problems and frustrations; not the work requirements themselves, but rather the physical and mechanical environment. (We were, of course, probing for problems and needs in the physical environment of the work-place, but we also gave plenty of opportunity for reporting problems in the social context, and in the work situation. Further, we sought positive comments in these areas, as well as problems.)

b. Impressions and Attitudes about the Work Situation

In discussing their present work situation, roughly one third were negative, one third neutral and one third positive. In part at least, this reflects the fact that at present, government employees in our sample work in a number of different buildings throughout the Vancouver area, some of which are older but have not been modernized in anticipation of the new building. Analysis of the data suggests that another factor is also working here, however. The negative employees were mainly executives who have had their jobs for a long period of time. And, while they were the most negative about their current working conditions, it appears that they are also more concerned about moving to the new building.

Aspects of their working situation that employees liked tended to deal with people, with meeting and working with them. Convenience to the downtown area was also significant. Dislikes focussed on the comfort factors of heating and ventilating, followed by concerns about lack of space. We also probed for the things that employees would like to see the same if their department had to move. Roughly one quarter would want everything changed, one quarter thought everything was fine as it was, and about half talked about specific things being changed, or stay as it was. Top on the list of things being retained was "privacy", although its standing varied widely from organization to organization (each with its own functions and different facilities.)

What changes or improvements should be considered? In order of importance, they listed:

- new equipment (both comfort-orientation and easier working operation)
- heating and ventilating
- more space
- individual facilities, such as restrooms, lounges, eating places.

Respondents were given a list of 25 characteristics of an office that our prior work had indicated were likely to be considered significant problems in the office work situation. They were asked to state whether they considered each one a problem or not. Then for each of the characteristics that they had mentioned as a problem, they were asked whether they considered it to be a big problem, an average problem, or a small problem. In descending order, respondents listed: ventilation, temperature control, storage, employee rest area, lunch room space, size of work area, physical appearance of work area, office noise, privacy, equipment noise, machine noise, with the lowest item on the list being coffee breaks. When interpreting these results to provide guidance to the architects, it was necessary to take into account differences in response between various work groups, and other categories of respondents, since there were marked differences in some instances.

Employee responses, including those in the open-ended questions following probing, dealt with the perceived level of the immediate environment, and not with the larger scale environment. There was a strong feeling indicated that the larger environment of the building and its situation was a "given" and that there was not much one could do about it. The immediate office and its content, however, were considered as capable of being controlled and manipulated to give satisfaction or dissatisfaction rather quickly.

c. People-to-people Interaction in the Work Situation

The tables on place, duration, and

nature of people-to-people interaction showed significant variations from organization to organization and were consistent with our understanding and observation of the kinds of work people do in the various organizations.

41% of the respondents indicated that they have close friends (that they meet with outside the work situation) working with them. The majority of these friends work together and have similar jobs.

d. Use and Attitudes about Facilities and Services

We asked respondents to tell where, and how often, they shop and use other service facilities, and how much they spend at these places. We also asked about service facilities in their present office building. We probed for likes and dislikes about all these facilities. Except for banks and department stores, most of the shopping was reported as being done near the home. Probing revealed that choices of retail or service outlet was strongly affected by the perceived friendliness and/or personal interest of the people who served our respondents. The way people were treated and the service they felt they received were reported as substantially more important than price or product considerations. "I buy there because he's friendly," or "He takes care of me, he's interested in me."

The detailed responses to these questions and in particular the comments on restrooms and other facilities in their existing buildings, will, we hope, provide a control for future evaluation studies of the new building.

e. Use and Attitudes toward Transportation

The statistics on mode of travel, parking, etc., correlated very closely with other data that was available. About two-thirds used a car to get to work; nearly one in three of those coming by car was a rider, not a driver. Three-quarters got to work in less than 45 minutes, and 44% reported less than 30 minutes of travel. About one-third of the employees went along with someone else, mostly co-workers. About half of those who used cars to get to work also used their cars during the day for business purposes. About one-third of all respondents reported that there was nothing that they liked about travelling to work. Traffic was the strongest "dislike". For those who did like something, the car was convenient, the bus was relaxing and freed them from traffic worries, and 12% indicated in one way or another that they liked driving.

f. Recall and Attitudes about the New Building

About half the respondents were aware of a possible move of their office, without aid from the interviewer; the percentage of recall was much higher after probing, however.

When asked for characteristics that a future office building should have, and probed for relative importance, the following image categories were given, (most highly rated listed first).

- have friendly people
- comfortable
- secure
- dependable
- freedom of movement
- comfortable lounge
- eating facilities open to all employees
- privacy
- social atmosphere
- restrooms which all employees can use
- dignified
- atmosphere of enjoyment
- parking out of sight
- larger size (more area)
- feelings of activity

Part Two

a. Perception of the Environment

This section dealt with the way that the respondents perceived the place in which they work and their thoughts and feelings about what the building they work in, and its interior spaces, should be like.

We summarized the themes that recurred in our data, including: a physical environment that was not overpowering; a sense of warmth; a sense of animation; a sense of comfort; flexibility in the work environment and other ideas. We then expressed in "architect's language", both words and symbolic sketches, what we understood these themes to mean. We quoted, as examples, respondents' references to other office buildings in Vancouver.

One recently completed project was perceived as what the respondents didn't want, and felt was foreign to themselves and their organizations, because it was "slick, cold, impersonal". They did not want to be working in a place that was "smooth, shiny, cold, mechanical". We commented also that a thick, rough skin to the building might not automatically be the answer, for it might still be seen as monumentally heavy, oppressive and impersonal. A new office building that is highly regarded in the architectural profession was referred to by people working in it as a "giant concrete egg-carton", oppressive and impersonal.

The respondents indicated that they expected the new building to be "open spaced", and the few who did not desire openness were mainly aged 50 or over. The responses also indicated a desire for a clear separation between public areas and work areas. We tried to interpret these feeling to the architects in the context of the desire for an open and friendly environment.

The matter of status in the office, and the symbols and comforts that go with it, was picked up from the tables and the open-ended responses and suggestions provided to the architects for avoiding potential problems.

b. People relating to People

The feelings about the respondents' immediate work environments, drawn from their comments to the open-ended probes, suggested strong desire for clearly defined personal territory and frequently for privacy. These same people, however, expected and wanted an environment that was "open" and that was "friendly".

The privacy that was sought seemed to be more symbolic than actual. Privacy, therefore, should not result in barriers to close personal contact. Employees seemed to need to "see", to "feel", people working.

Employees tended to identify with the public, and felt that they had a good rapport with the people who came in to their offices. Employees did not want "barriers" between themselves and the visitors. (Our previous interviews with visitors had indicated that the visitors had a very favorable attitude toward the government employees whom they contacted. The visitors felt that the government employees were helpful and friendly.)

We were watching for indications of role conflict among employees who worked in open areas and dealt with public visitors, after our experiences on other projects. These government employees, however, seemed to find that giving the public complete, friendly and supportive service was consistent with what their fellow-workers expected of them. This was also supported by our observations of them at work and, as reported earlier, by the impressions of the visiting public. Therefore there was not a need to screen the areas where employees met the public from the staff work areas. This allowed public reception and counter areas to be part of the open office, which was desirable both in terms of the employees' expressed desire for "openness" and for other functional reasons.

c. Functional Requirements

Heating and ventilating problems were reported strongly but this appeared to be at least in part a reflection of the fact that many of the employees are now housed in older buildings with only radiators and open windows for temperature control. This was seen as more of a problem by women than by men and, in some present offices, particularly for executives, the situation was satisfactory.

Employees complained both about sound generated within the office and, in some locations, about sound from the outside. These and other concerns, as for food service and commercial service, were commented on for their effects on planning.

6. Experiences and Recommendations Regarding Methodology

a. Problems of Analysis and Interpretation

We had intended that the analysis would proceed in two stages. First the straightforward survey research reporting and behavioral interpretation would be brought to a smooth draft, ready to become Part One of the report. Then we would build on this foundation, translating the behavioral findings into pragmatic programmatic guidance to the architects, to be presented as Part Two of the report.

This was a change from the analysis procedure we had used in earlier studies. Previously, we had teamed a behavioralist and an architecturally based person through every step of the analysis process. We were satisfied with the results, but we felt the man-hours (and dollar costs) could be reduced. For the current project, we hoped to reduce the man-hours for analysis by reducing the time when two people or more were working at the same time. It didn't work as we had hoped.

When we started the analysis and drafting for Part Two we found we could build directly on the behavioral analyses reported in Part One for only a portion of Part Two. We found that we also had to go back to the original data, and work up through the computer printouts, to find specific kinds of information we needed. Only then could we provide appropriately tangible, specific text that developed the themes suggested in Part One into formal programmatic requirements. In effect, we ended up doing the analysis in substantially the same way as on earlier projects. Fortunately, the analyst who wrote Part Two was trained both in survey research and in architecture and could work back through the data effectively, but doing this so close to the deadline for presentation resulted in considerable time pressure and the rearrangement of schedules for other work.

In future studies of this kind, and given the capabilities of the specific individuals we find on the programming team, we will not again try to economize so severely; instead, we will revert to having the analysis, as for the planning and instrument design, be a team effort.

b. Limited Value of Statistical Precision

It is clear that the sample design, and the processing and analysis of tabular results, should be sufficiently precise that general trends and emphasis are evident and solidly supported. The end use of the data in planning the project, however, is remote, subject to intervening translation and interpretation. Specific percentages, or decimals of a percentage, for responses to particular questions, are not directly useful to the architect. He needs to work not with the statistics themselves, but rather with their consequences for his work. This places a heavy responsibility on the analyst. He works with a broad brush and avoids quoting numbers where possible; but he must be ready with enough hard numbers when called on to back up a recommendation, and to justify his line of reasoning.

c. Semantic Problems

We experienced some difficulty in selecting words that would have the same meaning to us as to the architects, for describing attributes of architectural form. The problems were overcome, but we feel a need for more work in this area. Our report included some sketches with the text, but the need to avoid being too specific in visualizations makes this method of communication even more difficult than using words.

d. Validation of Today's Paradigms

In our data and analyses we found much to support current ideas of how buildings should serve humane and socially-oriented values. We could have elaborated in Part Two of our report, adding further programmatic criteria that would have been supported by the data, but that, to the architects, would simply have been as incontrovertible as "motherhood".

e. Value to the Users

Some aspects of the data were of particular use to the users, the client organization. The study provided insights about some aspects of their use of space, and their requirements. It gave them also a "rational" basis for evaluating a design proposal, supplementing general judgement, experience, and personal preferences.

f. Need for Followup and Evaluation
The data will provide a base-line for future evaluation, after the new building is occupied. We hope that such followup studies can be a normal part of building programming work.

7. Conclusions

This study applied the pragmatic, cost-conscious methods of consumer research to a problem in architectural programming. The survey was useful and achieved its objectives. There is a need for further development of analytical procedures, and for more use of observational research. The study, and its utilization, should be validated as part of the evaluation of the proposed building, after occupancy.

NOTES

(All of the following studies were conducted by TEAG - The Environmental Analysis Group, under the direction of Gerald Davis.)

(1) Recent studies include:
Davis, Gerald, and Roizen, Ron, Architectural Determinants of Student Satisfaction in College Residence Halls reported in EDRA TWO, Proceedings of the 2nd Annual Environmental Design Research Association Conference, October 1970, Pittsburgh, pp. 28-44.

Survey of student housing needs for categories of behavior patterns, reported in Master Plan for Student Housing, Washington State University, August, 1970, unpublished report.

Air Travelers Attitudes Toward Airport Terminals, unpublished report for The Richardson Associates and the Port of Seattle, March 3, 1969.

(2) Reported as Visitor Survey, August 1970, unpublished study for Department of Public Works, Province of British Columbia.

(3) Reported as Employee Attitude Survey, April, 1971, unpublished study for Department of Public Works, Province of British Columbia.

MULTI-LEVEL INDUSTRIAL BUILDING: A POSSIBLE INCENTIVE FOR ADDITIONAL CENTRAL CITY EMPLOYMENT AND INDUSTRIAL DEVELOPMENT

William O. Lindow

William A. Gould and Associates, Cleveland, Ohio

The exodus of industrial plants from the central city to modern one-floor facilities in suburbia and exurbia has become a chronic complaint -- and ailment -- of central cities across the country.

Results of this migration have posed nearly insoluable problems to central cities. The unemployment rate is steadily climbing, city population is declining, taxable incomes, properties and goods are decreasing and consequently there is a multitude of vacant old industrial buildings, adding to the slums and blighted conditions which are reflected in increased building deterioration, non-taxable land and a variety of safety hazards.

In an effort to minimize some of these problems, a study of the buildings in central Cleveland was completed recently by William A. Gould and Associates of Cleveland, architects and city planners, under a technical assistance grant from the Economic Development Administration of the U.S. Department of Commerce.

An earlier survey of the Cleveland industrial space market, completed in 1965 and also sponsored by the Department of Commerce, indicated what everyone had expected: The Central city contained a growing number of obsolete or near-obsolete buildings and limited amounts of land for new industrial development. Furthermore , the most available vacant industrial land was scattered, usually small in size and high in cost.

The survey showed more than 6,400,000 square feet in existing building space was vacant and only approximately 56,000,000 square feet or 1,300 acres of undeveloped industrial land (2.66% of the total land in the City) was available. Twenty-six percent of the total was unusable because of poor topography, access, limitations of small size and shape or the site was to be acquired for freeways.

Although industrial space rental rates in the suburbs were $1.25 and up per square foot in 1968 as opposed to $1 and under in the city, industries found the suburbs more accessible and offered room for expansion, adequate off-street parking, fewer traffic, vandalism and crime problems, a generally better business atmosphere.

Those occupying aging multi-story industrial space in the central city were smaller service and repair firms and industries which must be centrally located, such as warehousing and distribution. Generally, advantages in renovating the older structures were found to be minimal because of the high expense and difficulty to change to modern plant operations, though some warehousing and distributing companies have renovated buildings successfully for their unique needs.

From the 1965 survey, Gould and Associates felt that one alternative to alleviate the problem might be a new multi-level industrial building featuring the most advanced design and engineering characteristics for efficient production. The primary objective would be to demonstrate that multi-level operations at inner city locations were operatively feasible. Secondarily, it might maintain a level of job opportunities necessary to contribute to a healthy central city.

Other primary objectives were to develop a high density industrial manufacturing and/or warehousing facility to permit intensive use of high cost urban industrial land which included:

- evaluating the planning, architectural and economic feasibility of a specific and real project through identification of a potential site
- programming, planning and development of appropriate standards
- conducting a survey of potential support from community users and leaders
- identifying existing construction and development costs and tenant rental rates
- examining unknown technical problems that would affect location, design and use of the building.

The secondary objectives were:

- to determine the extent in quality and quantity a multi-level industrial building would be a factor in retaining employment for inner city residents
- to investigate the influence of such a structure in retaining local industries which must relocate or improve their present facilities by determining advantages of location near an available labor supply in the central city

- to evaluate types of industries that could function within the building
- to select representative Cleveland-located industries which have a realistic need for such new facilities.

Approaching the feasibility evaluation as a community development process, it was essential to evaluate the community support.

There is a need for small and medium-sized industrial firms in Cleveland to operate successfully and with competitive flexibility. Though most leaders in the business community recognized the city's problems of industrial moves out of the city, the degree of importance that was identified varies from complete apathy to alarm

There was support for the multi-level industrial building from representative community leaders, but their financial support of an actual demonstration project hinged on its financial feasibility, the political support from City Hall and execution of an overall plan to improve Cleveland's total urban environment to insure success. No one would risk individual commitment. Also important was the project's priority among community leaders and how it would be coordinated with related key improvement projects, such as safety, schools, sanitation, housing, and social issues. No priority of importance was really established. The support of local foundation executives failed because they did not identify the real significance of an industrial development base for the economy.

The five industries were selected to possibly use the building--food processing, apparel and related products, printing and publishing, fabricated metal products, and non-electrical machinery. Reasons for choosing these industries were that all have the need of traditional or operational proximity to each other to gain advantage of suppliers and their competition.

Three actual site areas were chosen for more detailed evaluation. (See figure 1) In these areas, the unemployment rate ranged from 7% in 1968 in the predominantly

SITE STUDY AREAS

AND SELECTED NEIGHBORHOODS

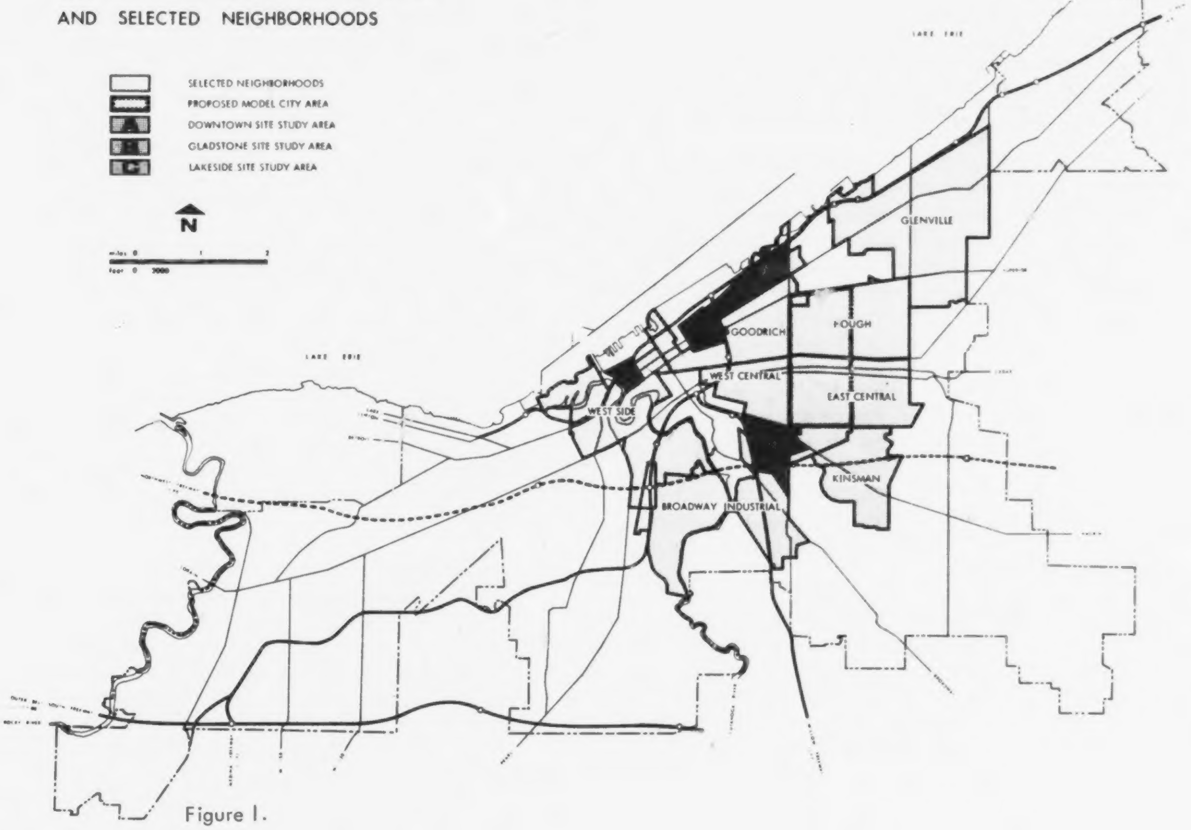

SELECTED NEIGHBORHOODS
PROPOSED MODEL CITY AREA
A DOWNTOWN SITE STUDY AREA
B GLADSTONE SITE STUDY AREA
C LAKESIDE SITE STUDY AREA
N
miles 0 1 2
feet 0 5000
LAKE ERIE
LAKE ERIE
GLENVILLE
GOODRICH
HOUGH
WEST CENTRAL
EAST CENTRAL
WEST SIDE
KINSMAN
BROADWAY
INDUSTRIAL

Figure I.

white neighborhood to 21% in the predominantly black area. Though the total city population was steadily decreasing, gross employment was reducing at an even faster rate, mainly because fewer manufacturing jobs, significant income producers in the central city, were available. In part, this was due to technological and automation changes, but principally, the move-out by key employers from the city can be identified as the greatest contributor to this deplorable situation.

It was, and is, almost impossible for skilled and unskilled workers, especially those in the minority groups, to move to the suburbs where restrictive practices prohibited these residents. Furthermore, public transportation to outlying areas could not assist in this problem and private transportation was unattainable for many of the members of minority groups because of the costs. Likewise, car ownership is difficult for inner city families.

Key factors in selecting a final site were based on availability of land, cost of land and the opportunity to give impetus to existing urban renewal and Model Cities projects in close proximity, plus meeting the objectives of working - living relationships.

Also affecting the feasibility of this innovation were zoning, building code requirements, detailed soil and subsurface conditions, financing and operating requirements.

The food processing industry (prepared foods, snack foods, frozen products, meats, cold storage, produce storage, packaging) was the primary choice for the detailed feasibility study. A 16-acre site was selected in Cleveland's Gladstone Urban Renewal Area (See Figure 2), adjacent to the Model Cities designated planning program - a potential source of labor.

The site had been cleared and immediately available from one owner, the City. There was possible flexibility for expansion of the site and the cost of land was favorable.

In addition, mutually beneficial relations could be established between future tenants and the adjacent Northern Ohio Food Terminal which has been traditionally the city's food distribution center.

A group of potential tenants from the food industry was identified by William A. Gould and Associates and a marketing consultant surveyed the group to permit a more precise definition of tenant needs.

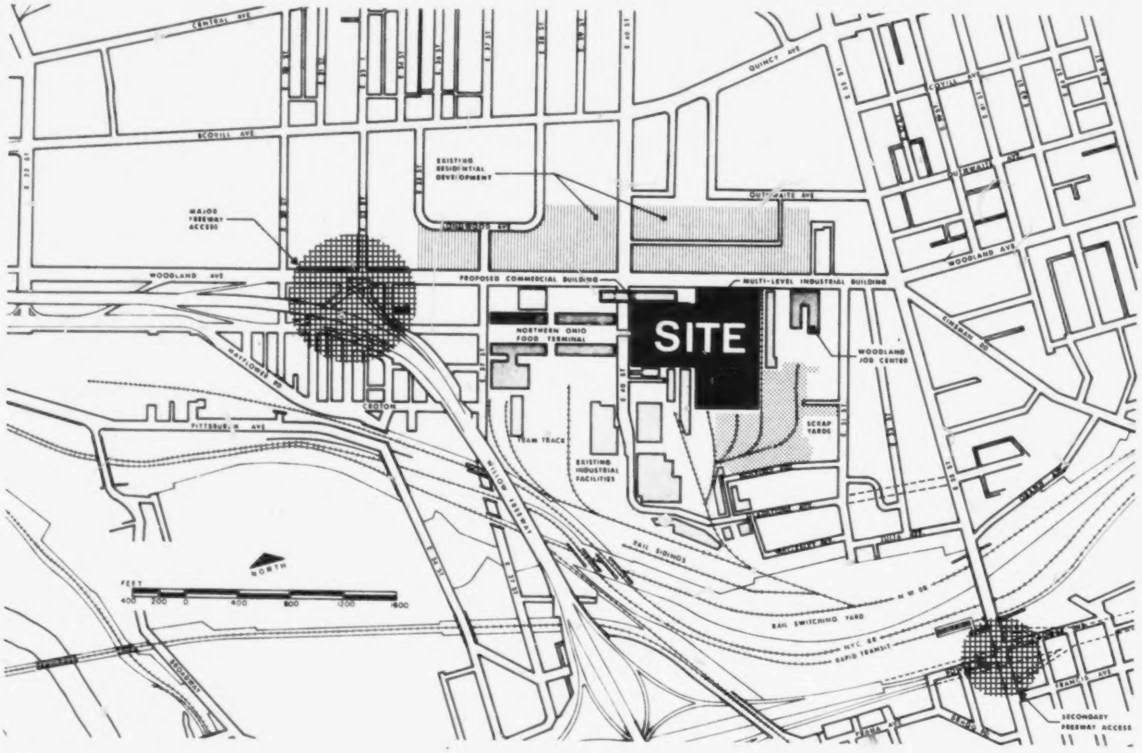

CENTRAL AVE
SCOVILL AVE
QUINCY AVE
COVILL AVE
OUTHWAITE AVE
WOODLAND AVE
EXISTING RESIDENTIAL DEVELOPMENT
MAJOR FREEWAY ACCESS
PROPOSED COMMERCIAL BUILDING
MULTI-LEVEL INDUSTRIAL BUILDING
SITE
NORTHERN OHIO FOOD TERMINAL
WOODLAND JOB CENTER
SCRAP YARDS
TEAM TRACK
EXISTING INDUSTRIAL FACILITIES
KINSMAN RD
MAYFLOWER RD
CROTON
PITTSBURGH AVE
WILLOW FREEWAY
RAIL SIDINGS
N W RR
RAIL SWITCHING YARD
NYC RR
RAPID TRANSIT
SECONDARY FREEWAY ACCESS
BROADWAY
E 22 ST
E 40 ST
E 55 ST
NORTH
FEET
400 200 0 400 800 1200 1600

Figure 2.

Gould and Associates then designed, priced and test-marketed three prototype multi-level industrial buildings, attempting with each design to determine a facility which would serve the tenants' operational and financial needs. Each prototype evaluation included parking, truck holding and docking facilities, warehousing, processing and support services.

Prototype Building One

Prototype Building One (see Figure 3) was a 13-floor structure, a radical departure from recently-built one-floor facilities in the industry. Upper levels would support a "processing tower" while lower floors would provide space for truck docking, warehousing and employee/customer car parking. The design called for all tenant firms to utilize common materials - handling facilities -- freight elevators -- thus creating a central management scheduling program that was thought to be a problem by those not visionary enough to recognize the potentials.

Street entrances led into a central core from which passenger elevators and stairways gave access to all levels. Space for warehousing or processing, truck docking and maneuvering areas was located in the sub-grade level. Levels one and two also had space for warehousing or processing activities, plus truck circulation and docking areas. Rail sidings with docks were located at level one.

The entire concept of "living on top of each other" was contrary to tenants' business instincts, as they visualized it. A totally-shared materials-handling system, as indicated in the market study, was out of the question to the conservative operators. Why risk the unknown if they could continue to do business as they had for years?

Furthermore, an evaluation of Prototype Building One showed there was no need for tenant space among the larger food processors, such as Kroger's and/or Stouffer's, for new space in the central city, since all either moved or were committed to move to suburban sites at the time of this evaluation.

However, a potential new, but smaller, tenant market within the industry was identified -- jobbers, purveyors, commission merchants and processor-wholesalers of foods. Though their functional space requirements were not met in Prototype One, they indicated an interest in this project.

The financial feasibility of Prototype One was based on total private financing and return on investment based on speculative building requirements.

Total cost was $26,449,300.00 which required an annual cash income of $8.37 per square foot of rental space, as compared to the 1968 rental market in the Greater Cleveland area which was $1.25 to $1.75 per square foot for new suburban space and $.65 to $1.00 in older existing buildings in the central city.

Prototype Building Two

Designed as a three-level facility (see Figure 4), Prototype Two provided space for processing and warehouse use adjacent to the truck service with parking on the roof for 470 cars. Space for warehousing or processing, truck docking and maneuvering areas was located on all three levels.

Each tenant would have private loading docks at each floor, controlling his own material handling. A total of 184 docks and 26 holding spaces would be allocated in proportion to the amount of space rented. An internal ramp system for forklift trucks was provided for materials movement between train docks and users on all building levels.

Total cost of Prototype Two was $16,489,760.00, which required an annual cash income of $5.99 per square foot, compared to $1.25 to $1.75 per square foot for new suburban facilities and $.65 to $1.00 in older buildings in the central city.

Though Prototype Two presented a functionally workable solution for smaller tenant needs, it did not appreciably increase building efficiency despite the elimination of freight elevators and common services. The primary reason for this poor efficience was the required provision for truck maneuvering space and docks on multi-level structure adjacent to the tenant's processing space.

In addition, the intensity of use would not appreciably enhance the employment picture for the central city, not attaining the public interest objective of maintaining jobs.

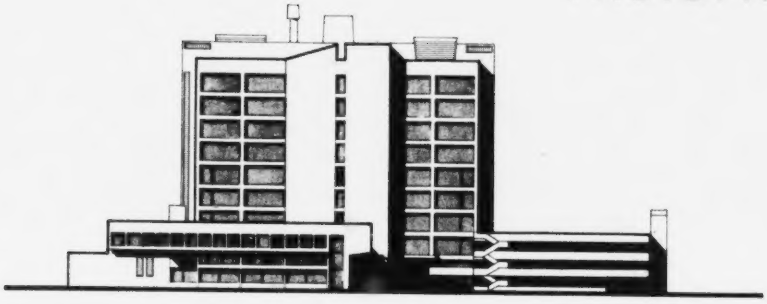
It also became apparent that initially a combination or joint venture of government assistance subsidy as well as private financing was necessary to make a multi-level building economically possible in Cleveland as a demonstration. The community and the federal governments were not ready for such an experiment.

Prototype Building Three

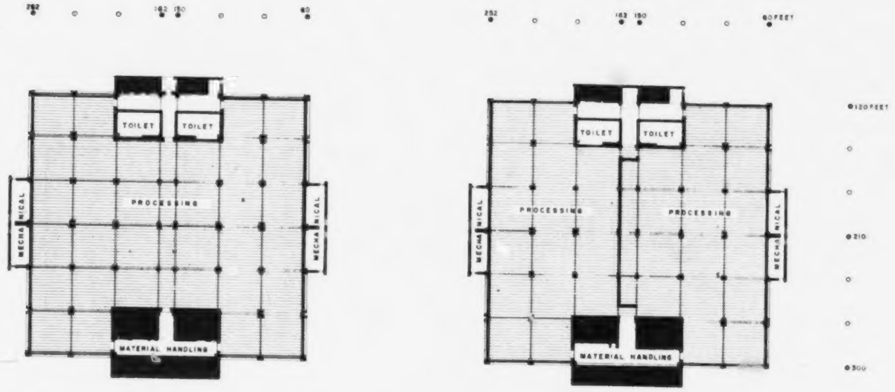
The five-level Prototype Building Three (see Figures 5 and 6) featured truck holding and auto parking in separate structures, allowing these facilities to be used by the Northern Ohio Food Terminal in addition to building tenants, thus giving double use to the materials-handling subsidized central facility.

This approach also permitted investigation of financing and development of separate building units by use, thus lowering the rental rate for the individual space. Since Federal EDA funds were known to be available, it was

PROTOTYPE ONE

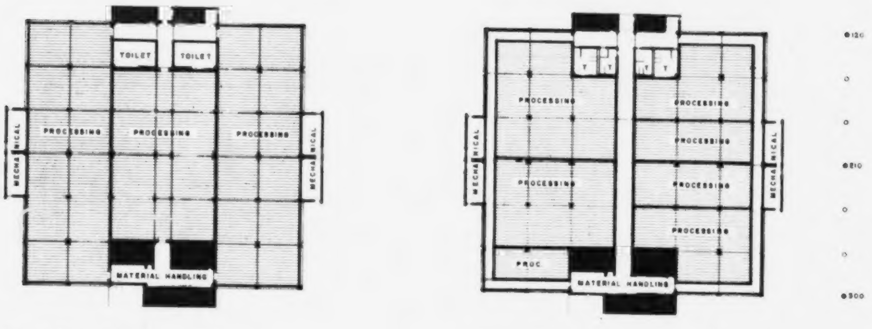


NORTH ELEVATION


252
162 150
60
252
162 150
60 FEET
120 FEET
210
300
TOILET
TOILET
PROCESSING
MECHANICAL
MECHANICAL
MATERIAL HANDLING
TOILET
TOILET
PROCESSING
PROCESSING
MECHANICAL
MECHANICAL
MATERIAL HANDLING

5TH LEVEL PLAN
TYPICAL 1 TENANT LAYOUT

7TH LEVEL PLAN
TYPICAL 2 TENANT LAYOUT


120
210
300
TOILET
TOILET
PROCESSING
PROCESSING
PROCESSING
MECHANICAL
MECHANICAL
MATERIAL HANDLING
PROCESSING
PROCESSING
PROCESSING
PROCESSING
PROCESSING
PROCESSING
PROC
MECHANICAL
MECHANICAL
MATERIAL HANDLING

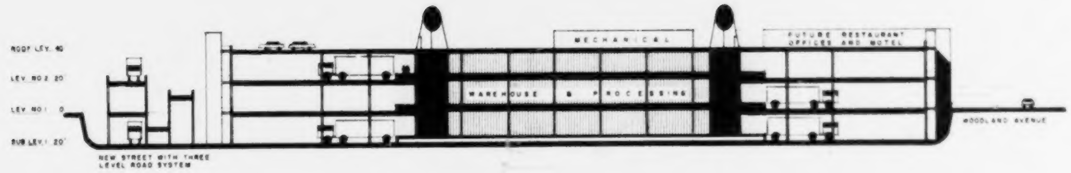
9TH LEVEL PLAN
TYPICAL 3 TENANT LAYOUT

10TH LEVEL PLAN
TYPICAL MULTI-TENANT LAYOUT

Figure 3.

631

PROTOTYPE TWO


ROOF LEV. 40
LEV. NO 2 20
LEV. NO 1 0
SUB LEV. 1 20'
NEW STREET WITH THREE LEVEL ROAD SYSTEM
MECHANICAL
FUTURE RESTAURANT OFFICES AND MOTEL
WAREHOUSE & PROCESSING
WOODLAND AVENUE

NORTH SOUTH SECTION A-A

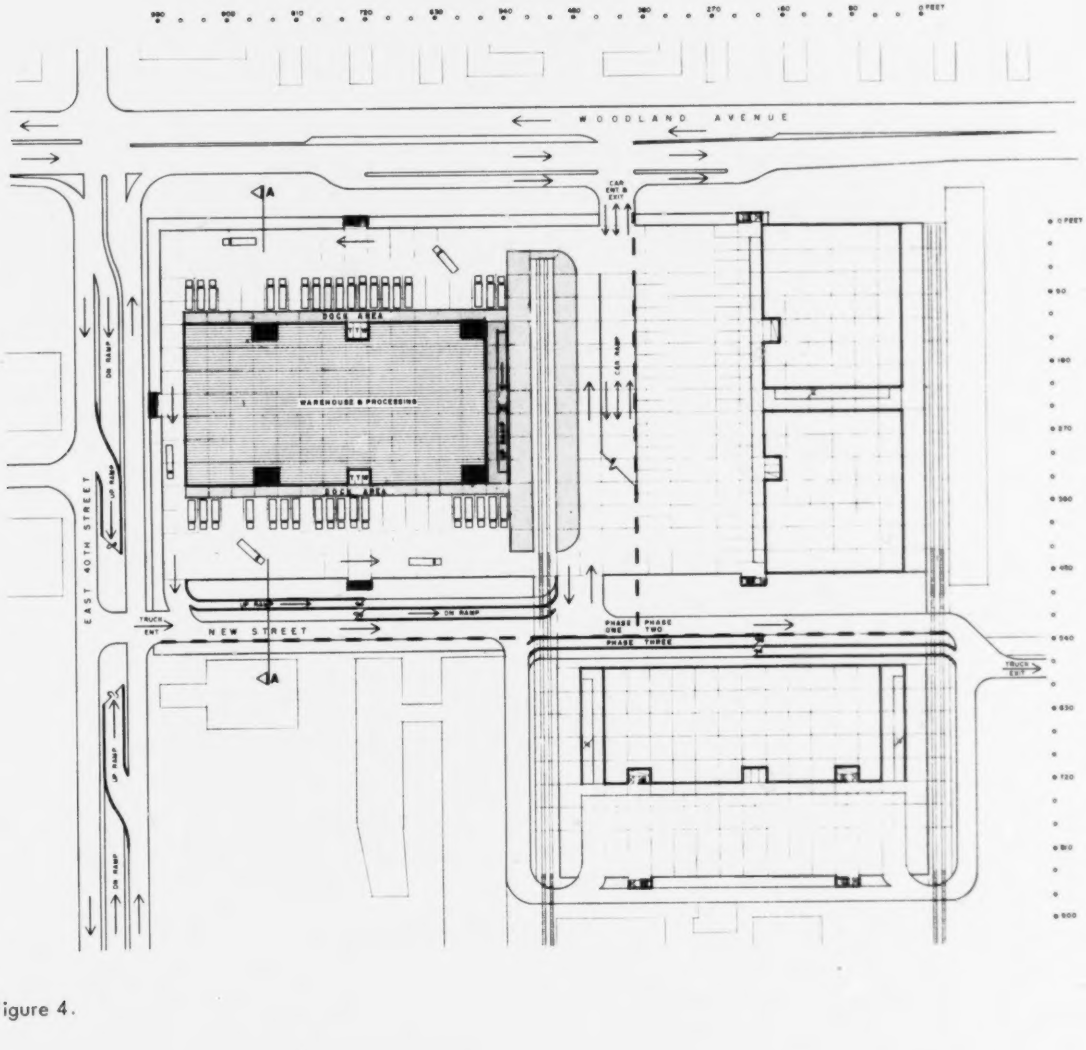

990
900
810
720
630
540
450
360
270
180
90
0 FEET
WOODLAND AVENUE
CAR ENT & EXIT
A
DOCK AREA
WAREHOUSE & PROCESSING
DOCK AREA
CAR RAMP
DN RAMP
UP RAMP
EAST 40TH STREET
TRUCK ENT
NEW STREET
UP RAMP
DN RAMP
PHASE ONE
PHASE TWO
PHASE THREE
TRUCK EXIT
A
UP RAMP
DN RAMP
0 FEET
90
180
270
360
450
540
630
720
810
900

Figure 4.

PROTOTYPE THREE

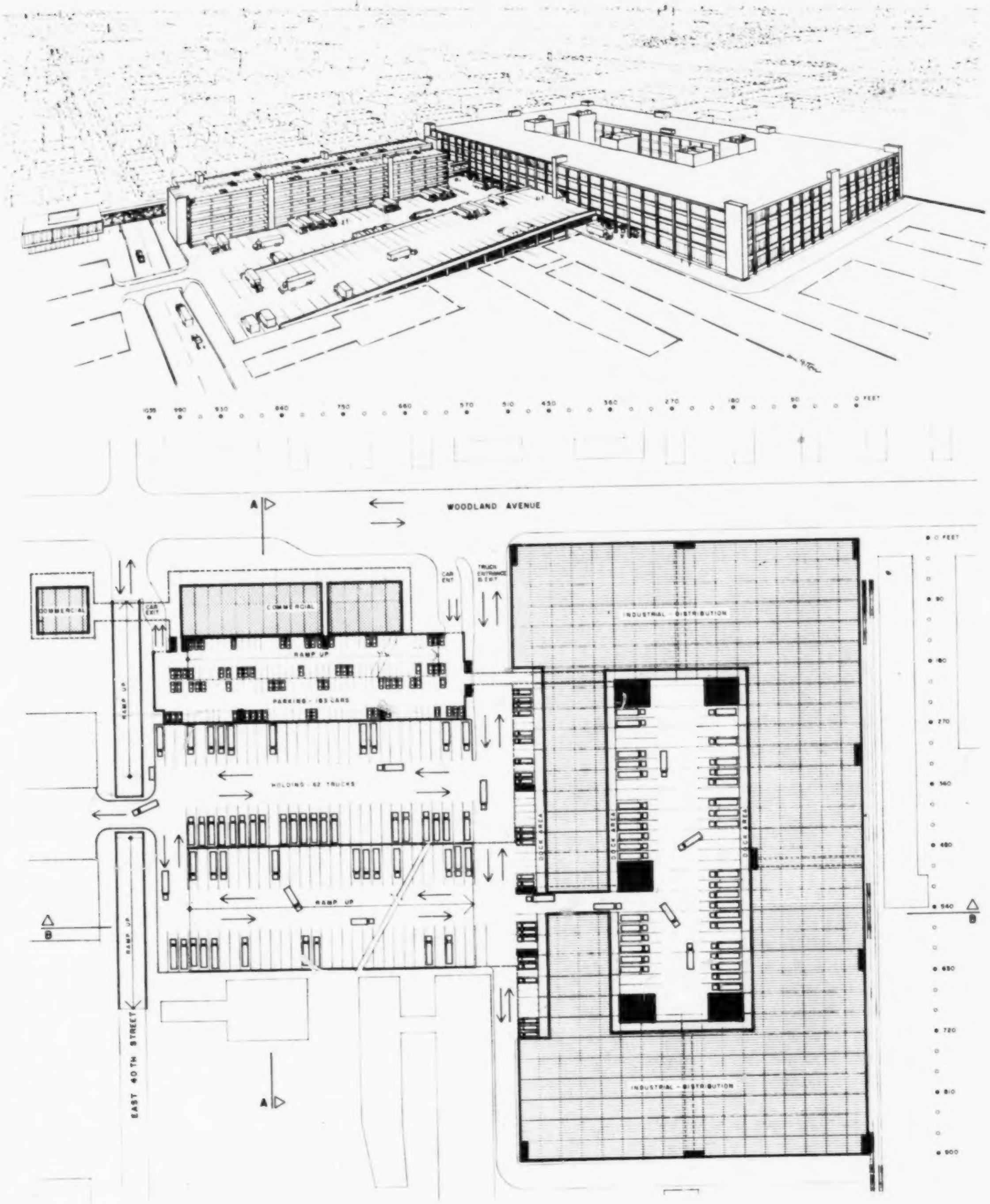
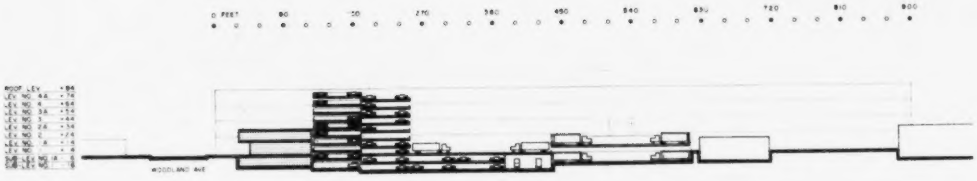
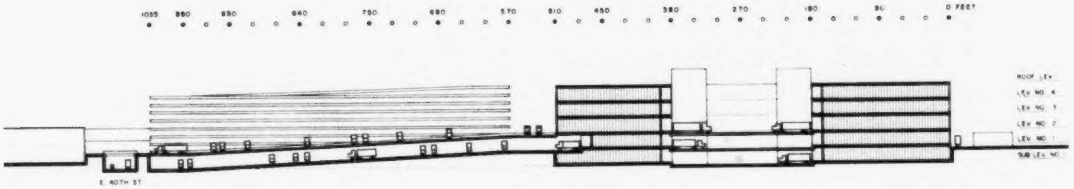

WOODLAND AVENUE
A
B
COMMERCIAL
COMMERCIAL
CAR EXIT
CAR ENT
TRUCK ENTRANCE & EXIT
RAMP UP
PARKING - 183 CARS
HOLDING - 62 TRUCKS
RAMP UP
RAMP UP
RAMP UP
INDUSTRIAL - DISTRIBUTION
DOCK AREA
DOCK AREA
DOCK AREA
INDUSTRIAL - DISTRIBUTION
EAST 40TH STREET
0 FEET
90
180
270
360
450
540
630
720
810
900

Figure 5.

PROTOTYPE THREE


0 FEET
90
270
360
450
540
630
720
810
900
ROOF LEV +84
LEV NO 4A +74
LEV NO 4 +64
LEV NO 3A +54
LEV NO 3 +44
LEV NO 2A +34
LEV NO 2 +24
LEV NO 1A +14
LEV NO 1 +4
SUB-LEV NO 1A -6
SUB-LEV NO 1 -16
WOODLAND AVE

NORTH - SOUTH SECTION A-A


1035
980
930
840
750
660
570
510
450
360
270
180
90
0 FEET
ROOF LEV
LEV NO 4
LEV NO 3
LEV NO 2
LEV NO 1
SUB LEV NO
E 40TH ST

EAST - WEST SECTION B-B

Figure 6.

decided they should be allocated to specific sections of the building, dependent on use and public good.

The major functions were housed in four separate but interconnected facilities: an off-street parking garage, a truck holding area, an industrial building and a central building service core.

Construction of the parking garage could be financed by the City using revenue bonds or general obligation bonds. Financing for the holding area and central building service core would come from a direct EDA grant to the City. The industrial building would be financed by an EDA loan covering 90% of the construction costs with the 10% equity coming from local non-profit sources. A tenants' association would be responsible for operating and maintenance costs of the central building core.

The parking garage would have a 2,188-car capacity in 10 levels -- two below grade and eight above. The holding capacity figure was based on the estimated number of employees in the industrial building plus the needs of the food terminal for additional parking. The garage would also serve the proposed supporting commercial facility within the building complex. There would be a pedestrian bridge link to the industrial building. The commercial support building would also be directly connected to the garage. The latter building would contain a bank, shops, etc.

The 186-vehicle truck holding area would consist of three tiers or levels -- one at grade, one ramping down to sub-level and the third ramping up to level two.

Service trucks, entering from the main thoroughfare, via an access road, would move either directly to the food terminal by traveling through the holding areas at grade, to a designated holding space or to a dock in the central building service core.

Access would also be available from the truck holding area to individual docks on all three levels with an on-site central electronically-controlled station near the truck entrance beamed to each holding and dock area for proper scheduling.

With a more broadly identified potential tenant market, the building had to be flexible enough for each tenant to achieve his individual operational objectives. Prototype Building Three provides a basic shell space for industries to make their own leasehold improvements. It was also concluded that this building could be adapted for diversification of industrial types other than food.

The central building service core would contain freight and passenger elevators plus mechanical (air conditioning) and electrical utility risers for all five levels -- one sub-level and four above. Industrial space would be constructed around the service core and would total 1,745,900 square feet of rentable space. Cold storage and general warehousing were planned for the sub-level area.

Total cost for the industrial building was $27,220,000 which required an annual cash requirement of $1.82 per square foot, as opposed to the $1.25 to $1.75 per square foot for new buildings in the suburbs and $1.00 and under for older structures in the central city. Costs for the building service core, the holding area and parking garage were not included, since they were to be financed by grants or to be self-sustaining.

It was assumed that tenants located on level one would need flexible scheduling and direct access to truck docks because of handling bulky goods or frequent deliveries and shipments. For these tenants with extremely high service requirements, docks for small trucks at grade along the outer western side of the building were planned in addition to those in the core of the building.

Truck docks on level two would be for the common use of tenants on levels two, three, and four. But levels three and four would be for distributors or manufacturers of small low weight bulk products. Scheduling would be handled by a central management service.

It would be possible for a rail spur track to be located along the eastern side of the building with dock space for up to 18 railroad cars. However, due to the nature of the building's use, the docks were not provided as part of the basic building costs.

A new concept of subsidized industry must be identified at the federal level, just as agricultural subsidies have been accepted since the 1930's.

Prototype Three could be implemented if a group of private firms have a primary location requirement in common or see a possible social need to justify participation as tenants in such a building. They would have to furnish the necessary equity in a non-profit tenant corporation and have the ability to accept from $2 to $2.50 per square foot in rental rates -- high for general manufacturing space.

An alternate idea would be for the city or federal government to recognize the ultimate need of retaining an industrial group in the central city because of its contribution to the city's economy through taxes, employment and a stimulation of the city's economy. This progress would also involve a non-profit tenant group, but the equity capital could come from other local sources, such as a non-profit foundation, of which there are many. A visionary dream, with federal support, could be a reality to save our cities.

The project did reveal that Prototype Three would yield $1,000,000 more taxes than a single - level facility, both being figured with the same number of employees per square foot and based on 40% site coverage for the single - level facility. The prototype would provide job opportunities for an estimated 3,490 persons while the single - level building would accommodate only an estimated 590 employees.

Conclusions

The obvious greater cost of a multi-level industrial building limits its use for specific urban situations, since the demand for industrial space in the metropolitan area can be met at lower cost in buildings in the suburbs. At least, this is true in Cleveland.

This idea can become a possibility when and if innovative structural, material handling and building systems are developed to the point of effective economical operations at a cost competitive to single-level building cost and operation. It can also become a reality when local or federal governments subsidize or develop the project as a social benefit for retaining employment opportunities, slum and blight removal, or to revitalize an industrial area or maintain the declining tax base.

Key factors which make multi-level industrial building more costly include the need for structural floors with heavy load-bearing capacity; the provision for services on structure, such as truck docking; warehousing and auto parking; the need for complex building service systems, such as elevators, stairs, mechanical and electrical requirements due to the need to run materials and people horizontally and vertically; unique safety and building code standards requiring fireproofing, sprinklers, emergency stairs, exits and separate ventilation systems.

Best suited for mulit-level tenancy are light manufacturing operations with minimum to moderate material handling requirements, preferably low bulk goods and moderate truck delivery requirements that can be scheduled for dock usage.

None of the three prototypes cost at levels of investment competitive with one-floor construction. But it should be emphasized that higher than average construction costs, the availability of suburban sites and the soft market for space in old buildings were all variable factors in Cleveland in 1968, which in other cities could have been more favorable to this type of project.

Assuming subsidies from both the city and federal governments are available, the break-even rental rate for the third prototype design was $1.82 per square foot at 100% occupancy for a building of 3 million gross square feet and this 1.8 million square feet of rental space is a possibility. However, the concept of federal subsidy has to be made viable in Washington.

Specifically, subsidies would include a 90% EDA loan for the industrial space, city revenue bond construction of the parking garage and an EDA grant to finance the holding area and the central building service area.

The $1.82 per square foot figure is about 25% greater than suburban one-story building rates and as much as $1.25 greater than rates for space in old multi-story buildings in the central city.

However, it should be pointed out that the result of any such analysis is dependent on the particular industry analyzed. Obviously, food processing presents special problems in handling because of high bulk and weight in relation to value. Odor, waste disposal and spoilage also are problems related to the food industry.

A building designed for light loads and a simpler material handling system would rent at approximately 20-25% less. However, it might still be too costly for Cleveland.

And until land in suburban areas becomes scarce and consequently more expensive, it is likely that a multi-level industrial building will not be economically feasible in central Cleveland in the private building market.

In the meantime, socio-economic problems in the city caused by industries moving out continues with fewer employment opportunities, declining population, old buildings and minimal vacant industrial land and must be fought by the city, operating on a limited income that must also support and expand vital services, school programs and redevelopment projects oriented primarily to housing for its citizens. Industrial attention has not become a top priority in the city political life.

From this research, Gould and Associates recommends that the city develop an on-going aggressive industrial redevelopment program, having as its goals to maintain and increase the city's tax base, retain and boost employment opportunities for its residents, to improve the general environment of central city neighborhoods, keep and add to the city's industrial base of small and medium size firms, provide initial space for new Negro-owned businesses, to sustain certain marginal businesses because of their unique and necessary services and last, but not least, attract new business to the central city (principally high employers).

To attain these goals, it is readily apparent large amounts of money and time must be committed by both the city and federal governments to this program. The question is: Are they ready?

This redevelopment program should include:

- General planning to give the city the most efficient use of industrial land by providing both single level and multi-level building sites.
- A plan for replacement of obsolete buildings and relocation of firms now operating in them.
- Provision for land assembly for new sites.
- Provision of off-site improvements, truck holding areas, utilities, auto parking facilities and other amenities to attract new industry.
- Provision of police and fire protection and other city services.

The fact that privately financed and built multi-level facilities exist in New York City, Chicago and in Europe illustrates that such development is economically feasible under certain conditions.

THE ANALYSIS OF BEHAVIORAL REQUIREMENTS IN OFFICE SETTINGS

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In recent years, the corporations that build office environments and the design professionals who plan them, have become increasingly, and often painfully, aware that their decision-making has a very real effect upon the behavior of those people who occupy and utilize the offices. It is obvious that these behavioral contingencies must be assessed in such a manner that they might be incorporated into the design of the physical environment. However, the question arises as to how best to accomplish this complex task, dealing as it must with a necessarily amorphous body of information and relationships.

The problem of relating the behavior of the users of an environment to the design of that environment is a two-step process. The first is the determination of the behavioral needs of the users. The second is the translation of these needs into physical environmental components. This paper is concerned with the issues of the first step: the analysis and development of behavioral requirements. There are some basic issues in the analysis of behavioral patterns in the context of the physical setting. Since it has been determined that behavior in relation to a physical setting is dynamically organized, and a change in any component of the setting will result in a change in the characteristic behavior of that setting (1), an important consideration of any analysis would then be the determination of the ongoing patterns of behavior that will remain constant when the organization changes its environment either by relocating or by modifying the existing environment. Another issue in the analysis was the relationship of the physical environment to the behavioral patterns; this is an essential issue in that the designer must understand what effect his manipulation of the physical elements of the environment will have on the behavior of the users. If the analysis is to lead to an environmental program, those physical elements which have an effect on the behavioral patterns must be understood. Still another important issue is the examination of all units of behavior within the setting. To understand the behavioral components of an environmental ensemble in holistic terms, three units of behavior must be analyzed, both as separate entities and as interrelated components. These three components are: organizational, social and individual goal-directed behaviors.

The purpose of the analytical stage of the process is to systematically record and analyze the ongoing behavioral patterns that would be affected by design decisions. The second phase of the process would develop this behavioral analysis into an environmental program which would specify the nature of the physical environment. This second phase was the subject of another paper and so will only be outlined in this paper. (2)

Rationale

Several theoretical considerations strongly affect the relationship of behavior to the physical environment in a set of corporate offices. Forming the basis of our analysis, these considerations include the spatial and social psychological base of organizations, activity systems, behavioral settings, communication patterns and perceptual identity within an organization.

A corporation is a complex social organization consisting of structured functional and social components in which people behave in an interrelated fashion according to the norms, values and roles existing in the context of the goals of the organization and which have the acceptance of its members. A social organization is a patterning of activities which reduces the variability of human behavior by means of three types of pressures: task requirements in relation to satisfying an individual's needs, demands arising from shared values and expectations, and reinforcement of accepted rules. (3) The nature of an organization is defined and its boundaries are determined by the relationships and patterns of behavior involved in the process of achieving its goals.(4)

An organization will establish sets of roles for its members to perform organizational tasks and to relate members to each other. These sets of role behaviors formalize the expected interdependent behavior of the members and represent standardized forms of activity (5). Members of social organizations have strongly held expectations about their role set and the role set of others, which includes the physical setting in which the role behavior is to take place. Overtly, they will attempt to communicate their expectations for the roles to be played and will exert pressures upon the individuals involved to conform to this role set, exhibiting stress symptoms if these expectations fail to be met (6). To insure that these role behaviors are established, a task-oriented organization will exert influence on the behavior of the individual members by dividing the work among the members, establishing standard practices and systems of authority, providing channels of communications and training new members (7). By doing so, the organization develops a set of norms which make explicit the forms of behavior considered appropriate for its members and a set of values which rationalize these normative requirements. A major determinant of an organization's system of norms is the type of activity in which the organization is involved (8).

Within the boundaries of the organization, behavior occurs which is not involved with organizational context, but nevertheless will exert some influence on the physical environment. These units of behavior are the social behavior of informal groups and secondary organizations, and the behavior of individuals. Because of the possibility for members of the primary organization to belong to other organizations, these overlapping secondary organizations become an adjunct component of the organizational environment. In addition, these organizations may or may not be concerned with the objectives of the primary organization. Another level of behavior within this category involves the social interactions taking place which are not concerned with the output of the organization. Since a person does not devote his entire fund of energy to the pursuit of organizational goals, the environment must allow him to pursue other behaviors than those required in organizational role performance. An individual will also attempt to organize his environment to give the maximum freedom of choice in behavior (9). These extra-organizational behaviors must be identified and analyzed as part of the holistic environmental system.

Because of the purposeful and goal-directed nature of an organization, it will divide its activities into specialized subsystems to achieve optimum efficiency of means. These subsystems are in the terms of the corporation, departments, work groups or task forces. The subsystems interrelate with each other and the relationships and linkages between them determine the nature of the organization and will affect the behavior of its members.

When considered as an ecological unit, the organization determines its environment by controlling the activities taking place within its boundaries through certain processes. An organization will distribute activities spatially and will prescribe regions for these activities to take place. It will also control behavior by segregating one behavior from another and establishing normative behavior for each setting. Ecologically, organizations also establish the rhythm and the tempo with which activities take place. Finally, the organization controls the time sequence of the activities taking place (10). These ecological processes both temporally and spatially construct the activity system of the organization. An activity system develops when a behavioral unit such as an organization, a social group, or an individual, exhibits regularities in the content and ordering of its activities in time and space (11). The activity system consists of those discrete behavioral episodes that have meaning by being purposeful and is influenced by environmental constraints. Because an organization locates its activity system spatially and temporally, ongoing behavioral patterns can be studied in relation to its physical setting (12). This relationship between behavior and its setting can be further studied by analyzing its dynamic organization (13) and characteristic behavioral patterns can be identified. Since the behavioral patterns must be compatible with and are closely related to the physical place in which they occur, components of that physical setting can be studied as to the effect on these behavioral patterns. This active and continuing process in which the components of both the physical and the behavior systems are defining and being defined by each other establishes a meaningful system of feedback between the elements of the environment (14). It is this manner in which the physical environment supports the organizational system and the patterned behavior of its members.

Methodology

The method used to collect the data of the research under discussion was an interrelated system comprised of interview, structured observation and user questionnaire techniques. Because of the complexity of the material being sought, no single method would have been able to fully ascertain the required data. Each method also had some inherent weakness which would tend to produce either incomplete or confounding information. Therefore, it was necessary to develop a system which would permit the

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gathering of the various kinds of information by the most effective and pertinent means. Another facet of the system for data collecting was that each of the three parts of the system contained some internal checks upon the information gained through the other methods.

Initially, the investigators visited the existing location of the facility and informally observed the corporation in action. This was then coupled with a series of non-directed interviews with management about the nature of the organization in order to form the context of the investigation. From these two activities, an investigation strategy was planned and the instruments tentatively drawn up. These instruments would be free to respond to any significant areas warranting further investigation or in the event that more complete explanations were required to clarify a situation.

The first method utilized was a series of structured interviews with both executive level and line management level personnel. The information sought during this period focused on the attributes of the particular work subsystem and its relationship to the larger organization and other subsystems. Questions were also directed toward broad classifications of variables and attempted to uncover any dysfunction or dissatisfaction with the existing environment. The categories of information sought were organizational structure and policy, spatial description of the work flow, activity, communication and interaction patterns, ratings of tasks performed by staff, description of felt needs in spatial organization and ratings of the existing environment in terms of fulfilling these needs, indications as to the structuring of the existing space, the felt needs in the perceptual qualities of the space, and future trends affecting the group's function and environment.

The second method was the systematic observation of the environment and behavior taking place within it. The observations took place for a period of thirty minutes and were repeated a number of times throughout the investigation. The initial step was to map the behavior as it occurred within the setting (15). This entailed the recording of the discrete behavioral episodes as they took place; these were then categorized and a behavioral setting inventory compiled (16).

This inventory included both recordings of the behavior which took place and descriptions of the physical setting in which it occurred. The physical description contained the patterns of spatial organization, the physical and functional distances between occupants, visibility of the occupants to each other, the distractions and interferences present in the setting, the boundary conditions, the power cues perceivable and the overall physical character. The activity pattern of the setting was encoded to describe what categories of activities were taking place and rated along scales of participation, involvement with other activities, and the tempo with which they were taking place. The behavioral mechanisms required to perform the activity were recorded and rated along scales of participation, tempo and intensity. The mechanisms recorded were affective behavior, gross motor activity, manipulative activity, verbalization, thinking, variety of behavior, pressure to enter the setting, and penetration by outsiders.

The social mechanisms were also recorded and rated. These were type of authority system, interdependence between this site and others, population density, occupancy time, and temporal loci of occurrence, duration and recurrence.

The third method of gathering information utilized was the user questionnaire. These questionnaires were distributed to all members of the staff. The information sought was concerned with the nature of the activities the individual pursued and his attitudes toward and perceptions of the environment and organization. Information was also elicited concerning the felt needs of the individual. Within the first category, information included descriptions of their jobs, time breakdowns of activities performed and task-related social participation, ratings of tasks along several adjective scales, and sociometric data about communication patterns, authority interactions, locational preferences and work flow. In the second category, individuals were asked to rate the environment according to its physical and social attributes. A series of questions concerning how they perceived the various aspects of their environment and the organization in general were presented. The employees were asked to give their requirements for an optimum working environment and to describe any dysfunctions within their current environment and work stations. In addition, questions were asked that elicited information required for explanation of problem areas uncovered during the first two information-gathering methods. These questions were generally concerned with employee attitudes toward working within a specific problem environment, the manner in which they performed some activity or how they spent free time within the organizational boundaries.

The material produced by the above methods was analyzed by combining and comparing the resultant information and was mainly concerned with identifying the factors related to the behavioral-environmental interface. Any discrepancies were discussed with the people involved to ascertain the nature of the conflict. Three units of classification of the material for analysis were employed: organizational structure, spatial distribution, and job categories. In the first unit, the material was plotted according to the various components of the organization and analysis was constructed around organizational criteria. The second unit required that the information be organized in a sociometric diagram and analyzed according to the attributes of the physical setting. The third unit required that the data be broken down into job categories and analyzed by the task requirements and hierarchical position. A final analysis was conducted by comparing the three units as separate bodies of information.

The Activity Site Model

The analysis of the behavior in the process of taking place within the corporate environment led to the concept of activity sites as constituting the model with which to develop the behavior-environment interface. This concept binds the organizational activity systems to the organizational space in which they occur. An activity site is a physical area within the organizational boundaries in which a prescribed activity recurrently and regularly takes place; this activity is purposive in that it is directed toward the achievement of organizational or corporate objectives and is controlled by organizational rules. Another facet of the concept is that because of this purposefulness of the activity, all activity sites are to some degree interrelated and are linked together to form the corporate environment.

The activity taking place within the site is patterned behavior required to carry out the continuing cycles of events to achieve the organizational goals. The behaviors can vary over a period of time and behavior not concerned with corporate objectives may occur. The primary attribute of the activity site is the relationship between the behavioral patterns and the physical site in which they take place. Because of this interdependency, an activity site can be described in either its physical or behavioral components. A description of one set of components can be used to specify the components of the other.

Within the context of the corporate environment, the activity site can be viewed on several scales, depending upon the level of analysis. If the corporation is being studied as a totality, each department would then be considered as a separate activity site. The audit department, for example, pursues a particular system of activities in a physical setting; these are significantly different from those taking place in the accounting department or the research department. In the next lower level of analysis, the immediate environment of the work group can be considered as an activity site. At this level, scaled comparisons can be made on a more discrete level of analysis and the behavioral components of work groups can be examined across the organization without reference to the departmental structure. The final level of analysis is the consideration of an individual's work station, whether it is a desk or a suite of offices, as a separate activity site. This scale is used to analyze the smaller scale and individual considerations of the environment. Task activities can also be compared throughout the organization. By considering the activity sites as a system of parts, the smaller scale activity sites can be organized hierarchically to form the corporate environment.

Another area in which the activity site concept was a tool for analysis was in the area of extra-organizational behavior or social activity taking place outside the context of the organization, consisting of informal social behaviors that occur without a formal structure of their own. These behaviors function to humanize the organization and to relieve some of the organizational stress by establishing informal contacts among members of the organization. If an office environment is to be successful, the physical environment must be able to foster such behavior. The activity site model can be used for analysis within a context by reducing the weight of the organizational components of the model.

Behavioral Components of the Activity Site

To describe the behavioral components of the activity sites, it was necessary to develop a systematic method which would be capable of describing behavior over a number of different sites. We termed this method of description a genotypic function typology, which refers to the activity performed by a unit of the organization as part of its function within the larger organization. The typology divides behavior into three subsets: task, social and organizational behavior.

What we have termed task-related descriptors include those behavioral components created by the task itself, as performed by the individual or the group. The category of the activity in which the site is engaged gives a very general indication of the ongoing behavior within the activity site.

> The level of activity is the specification of the amount of physical activity actually required to perform the task. Two types of activity must be considered: gross motor activity, and the manipulative activities involving fine muscle control.

The level of thinking describes both the type and the intensity of thinking required for the performance of the task. Here it is necessary to determine whether the occupant is involved in problem-solving, decision-making, or rote mental activity. An intensity dimension is required, as well as a dimension of differentiation in thinking activities.

The level of routineness present describes the amount of repetition in the performance of a task over a period of time and whether the task is varied in nature.

The level of attention indicates the type, as well as the intensity, of selective attention which must be maintained by the performer.

The orientation of the performer involves a description of the central focus which must be maintained to accomplish the task; it can be a physical or a non-physical element.

The volume of work refers to the actual physical amount of work which is completed by the performer during a specified temporal period.

The social considerations of the activity system describe those elements which tie individual members within the activity site together into social groups. In this way, the first level of the social structure is formed.

The amount of social structure and the formalized role systems discernible within the group provide the initial dimension. This has reference to the presence of behavioral patterns which are anchored in the attitudes, perceptions, beliefs and motivations of the inhabitants of a social space. The formalized role system is the explicit formulation of rules which define the interdependent behaviors.

A second criterion involves the interactions related to the task which are required for its performance. This becomes a description of the communications patterns serving to form individuals into groups. These exist along two dimensions: type and intensity. Another characteristic of these interactions is that they are purposeful in that they exist because of the needs of the activity. In sites where a low level of task-related interaction is required to perform the task, a second level of social interaction takes place which serves to link the group together.

The communication patterns that tie one group to another constitute additional criteria. These criteria permit the examination of the links existing between groups or between individuals on several levels, such as frequency, mode and purpose.

The level of supervision required to ensure that organizational objectives are being met describes the exercise of authority within the site and the amount of choice afforded an occupant in selecting a behavior pattern.

The social focus of the performers in the sites simply describes the group in terms of its type and size within the larger setting.

Organizational considerations of the genotypic function of the site are those components that describe the organizational behavior. Since the organization effectively controls much of the behavior which takes place, it is necessary to categorize those aspects of the organization which have an effect on the behavior of individuals and on the physical environment.

The value system as held by the leaders of the group describes the ideological justifications and aspirations of those who have control of the system. This buttresses the authority structure and the behavior of the system. Such a dimension can be described on a continuum from pragmatic to transcendental.

The system norms make explicit the forms of behavior which are appropriate for members. These are accepted by the members as being relevant and desirable. These can be scaled along three standards: the acceptance of appropriate behavior, the commonality of the acceptance, and the awareness of group support for this acceptance.

The outcome of the activity provides a measure regarding whether the activity is immediately and directly involved in the primary product of the organization, or whether it is involved in influencing other subsystems.

The type of reward system describes how the members receive their rewards for task performance. Two types of reward systems are the expressive cycle and the instrumental cycle. The expressive cycle refers to rewards based on personal fulfillment of the individual in the performance of his role; the instrumental cycle refers to rewards based on pay and other external considerations.

The type of authority system describes how management expresses its control over its members. Theory X refers to the reliance on authority as the primary means of control, and it is reductive in intent. Theory Y relies upon the motivation of the performers for control and it is developmental in intent (17).

Activity Site Linkage Considerations

Since an organization must divide itself into functional subsystems and will distribute activities within its boundaries, the organizational environment will consist of a myriad of activity sites linked together by various ties. The type of links existing between activity sites and the strength of these links is a function of the type of activity that takes place within the sites. Some linkages are networks that span the entire organization, while others will only connect several sites together.

The most common linkage is that communication network which ties one site to another by the flow of information required to perform the task of that site. These networks are usually established across the organization in relationship to its character and the nature of the activities. Two types of communication networks exist normally within a corporate environment, a formal one which is defined by organizational policy, and an informal one which develops outside that policy. The character and function of the information can be analyzed by the direction of its flow.

The characteristics of some activity systems required that other forms of connection take place between sites. One classification is functional connections of work flow, material flow, and paper flow. In a situation where the activity is part of a larger ongoing system or material that was utilized or produced within another site, or a large volume of work passed between sites, the most important locational criterion was the ease with which the work or material flowed between sites.

Because of organizational goals or values, other activity sites were located by considerations of status. To increase the status of an activity site to reach some organizational objects, it was located within the perceptual sphere of a high status site so that it may share its perceptual identity. In addition, activity sites were connected by power networks which were generated by the hierarchical organizational structure.

The final means of locating activity sites within the organizational territory was the compatibility of activities, physical settings or populations. This category of linkage operated when there were no other available criteria to locate the sites. It was also used to modify the strength of other connections. Two sites have a communication requirement that represents a tie between them; however, if the activity patterns are incompatible, some dysfunction may result if it is not taken into consideration.

The linkage elements can be analyzed as to their character and strength and weighting can be given to each. This then can be utilized to establish the geographic distribution of the activity sites across the organization.

Conclusion

By systematically recording and analyzing behavior as it occurs in office environments, a program can be developed which relates the behavioral contingencies to the design of the physical environment. The activity site concept was developed to relate these behavioral and physical components. By doing so, it enabled the analysis of the behavior-environment interface and the specification of the supporting physical system by the utilization of socio-physical performance characteristics (18). These performance characteristics serve as a translating function enabling the program to relate the physical system and also enable the development of an environmental program by specifying objectives which allow the designer the freedom to choose from several alternatives in the process of his design.

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TRANSLATING PSYCHO-SOCIAL CRITERIA INTO DESIGN DETERMINANTS

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"Building is a decision-making process based from the outset upon attitudes toward people". Andrew Euston (H.U.D.)

This statement made by a government official and presented at a recent workshop on Socio-Physical Technology is but one more documentation of the growing realization and awareness by political leaders, government officials and planners that the ultimate responsibility of a design decision must rest with the consumer of the design product.

Irrespective of some efforts by the American Institute of Architects and a handfull of interested leaders in the profession, the facts are painfully obvious that the practitioner of the architectural profession and his non-professional counterpart, the developer, are not attempting to communicate with the consumers of built spaces. The skeptic may argue that everything we build today is in some degree experimental. The fact is that we have no effective way to measure the results of human criteria programming upon design. Short term economic success in terms of first cost or sale on one hand is compared to total failure in terms of riots at the other extreme.

The developer supposedly will respond to human criteria programming when a method of application can be perfected that is financially reasonable and the end result produces a more marketable product. It remains doubtful that the architect who has been trained in the Beaux Arts School of design will ever be able to fully support a method that usurps his opportunity to excercise the mystic powers of "the designer". If this statement appears harsh it is because it is intended to be harsh The society of America as well as that of all the world can little longer afford to be polite to a decision-maker who makes design decisions in spite of, not because of, the people who will ultimately occupy those spaces created by his intuitive decisions.

The experimentation reported in this writing is one which does not profess to discover new insights in the technology of human-ecology. Instead the task undertaken here is to study and evaluate existing technology in the social-psychology field for direct application to the design process. The translation of a measurable value from the social science discipline to the jargon of the design professional in an effort to establish a value accepted by both disciplines to be applicable to the design process was the postulate under which this research was initiated.

Until very recently virtually all behavioral research was carried out with species of the aniaml kingdom other than man being observed and tested. Early human ecological reports extrapolated from animal studies their data to hypothesize human tendancies. These reports appeared to be divided into three logical divisions of behavior characteristics; sociability, agression and territoriality. These three characteristics were exemplified environmentally through acts called rituals and routines which were carried out within the constraints of the environment. The ultimate value that signifies satisfaction of people with their marriage to space was recognized to be happiness.

It should be mentioned that in a very few occasional and isolated instances, an architect somewhere in the world through creative genius, sincere concern and dedicated application, intuitively answers the complex requirements of the social science discipline; and a designed environment of exceptional quality is built.

It makes very little difference whether a designer designs a schoolhouse or a penitentiary until the behavioral requirements of the anthropometrically shaped animals who will occupy the spaces are considered. People are people; but every person is different from all others in some small or perhaps major way.

A test case was established for this study and carried out in an effort to recognize the potential assimilation of behavior criteria into the design process. The Australian Mutual Provident Society, New South Wales Branch, allowed the testing and observation of three departments in their Sydney Cove Office Building. The Department of Group and Collector New Business, Department of Agency Accounts, and Department of Ordinary Statistics provided 97 clerks (69 females and 28 males) ranging in ages from 16 to 64 for this study.

The Investigation Method.

The proxemic notation system developed by Dr. Edward T. Hall, noted social-antrhopologist , was used as the basis for this investigation. Each observation period lasted one hour; and an observation obviously deemed non-typical of the individual clerk was ruled out; and the clerk was retested.

It was then observed and subsequently hypothesized that three characteristics of an individual's personality primarily motivated his behavior in the work environment during the execution of his clerical routine. They were:

1. His aggressiveness when he interacted with others.
2. His sociability or requirement for companionship with his fellow clerks.
3. His need to know and establish the limits of his working territory in order to satisfy his requirement for privacy and sometimes personal identity.

In order to determine the clerk's aggression requirements and his limits of territoriality, a test questionnaire was developed using questions requiring selection of seats at a table in occupied and unoccupied conditions. Dr. Robert Sommer, a social-psychologist from the University of California, has employed this method of selection to recognize optimal retreat patterns and territorially orientated limitations of physical environments. Leading questions were also posed during interviews and on questionnairesconcerning current issues in the working environment in an effort to document the aggressiveness with which each individual clerk responded.

An observation charting the degree of friendliness of each clerk to others as well as others to each clerk was made. Each individual clerk was then asked to rate himself regarding his friendliness and lastly to rate others similarly. This investigation was made in an effort to determine the degree of sociability of each clerk. They were then asked to indicate the people in the department with whom they most enjoyed working or just talking to. This information later helped to determine ideal neighbors.

From the information gathered, graphs were prepared to establish the average rating in each characteristic and individual relationships to the average. An observation was made that the requirements of aggressiveness, sociability and territoriality varied widely from person to person; and the patterns developed by the three elements in combination were not consistent. This observation vindicates an early conjecture that 'clerks are people'.

Preliminary Testing Results.

Ninety-seven clerical workers were given a preliminary examination to determine statistics regarding their identity and living patterns, cultural notation, and attitude towards their office environment. Ninety per cent of those tested listed Australia as the birthplace of their parents.

Given a free choice to sit at any desk in their department, 67% requested a change from their existing desk location. 64% of those gave environmental reasons for their move such as 'too much traffic around my desk', or 'I want to be near the windows for the view'. 15% indicated that they wanted to be near a friend' or 'where the action is'. 21% indicated that they wanted to move to another desk that represented more prestige.

Asked to delineate 'their own working area', 31% considered the entire department as their working area, while 53% included their desk area and the area of others in their work section as their 'working area'. 16% considered only their desk and chair as their working area.

Only 20% of those tested registered any concern with the lighting conditions of the office; and then only one person in the department chosen for the case study complained of insufficient lighting conditions.

Qualifications.

The physical environment is but one variable in our living patterns that affects our emotional, intellectual and physical well being. It is the combination of many stimulants that inspire happiness or satisfaction. It has been suggested that the physical environment is always a negative factor in determination of our well being ;while interacting with others. However, it must be mentioned that when man is called upon to interact independently with his physical environment, then the environment has positive potential. The popularized 'light show' and 'discotheque' activities are prime examples of man searching to reduce his interaction with the environment into a pure and total communication uninhibited by interference from his fellow homo sapien.

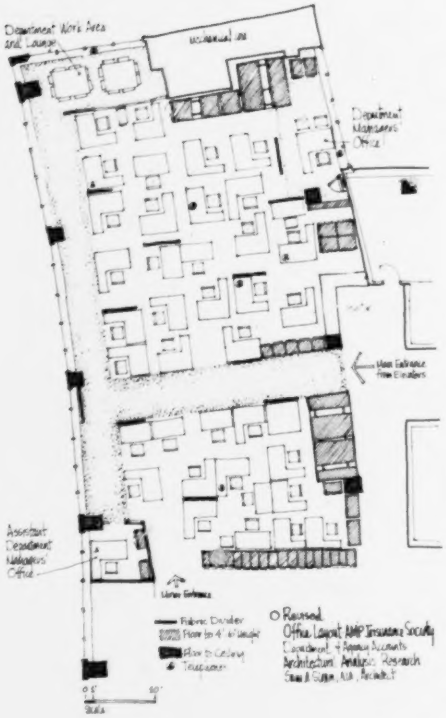
In the office environment, happiness and satisfaction result from a multitude of stimulants. Studies conducted by a psychologist, F. Herzberg, and his associates, B. Mausner and B. Synderman (1959). revealed that those elements that inspired a group of accountants and engineers to feel good about their work were accomplishment and the feeling of growth in job competence. What made them feel badly at their jobs were the most usually flexible elements; inadequate salary, poor working conditions, insufficient job security or poor supervision. If management accepts Herzberg's theory and dedicate themselves to promoting happy and satisfied clerks, this concept would place the employer in a position of attempting to reach zero with the negative elements that make a clerk feel badly while encouraging self-motivation towards task-orientated growth and accomplishment factors that make a clerk feel good.

It is important to recognize that ultimate happiness and satisfaction is dependent upon improving both the environmental conditions (or 'hygienic' factors as referred to in the Herzberg report) and the task-orientated satisfiers (or 'motivators').

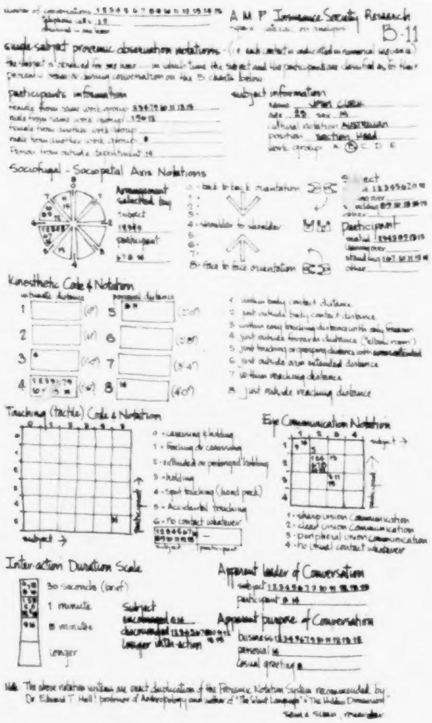
The architect is responsible to society in providing environments for occupation during the performance of tasks. The environment has climatic, physical, psychic, and social consequences upon man's performances. Mechanical and electrical engineering provides the architect with climatic systems capable of accomplishing extremely low tolerances in our physical environments. The study of ergonomics can provide architects with tolerances in conjunction with the physical limitations of use of artifacts in our environments. The disciplines that constitute the man-environment attitude in architecture concern themselves with the ergonomic, anthropometric, psychic and social consequences of environments upon man's performance.

Proxemics.

The study of Proxemics, developed by anthropologist, Dr. Edward T. Hall, deals with the subconscious tendencies of mans' activities in the immediate environment. He positions himself and the distances he maintains between himself and others is referred to as his proxemic relationship to others.


Department Work Area and Lounge
Department Managers' Office
Main Entrance from Elevators
Assistant Department Managers' Office
Fabric Divider
Floor to 4' 6" Height
Floor to Ceiling
Telephone
Revised
Office Layout AMP Insurance Society
Department + Agency Accounts
Architectural Analysis Research
0 5' 10'
Scale

Existing Office Layout



A M P Insurance Society Research

B-11

single subject proxemic observation notations

participants information

subject information

cultural notation AUSTRALIAN

position section Head

work group A [✓ B] C D E

Sociofugal - Sociopetal Axis Notations

Arrangement selected by

subject

participant

0 - back to back orientation

4 - shoulder to shoulder

8 - face to face orientation

Subject

Participant

seated

leaning over

standing

other

Kinesthetic Code & Notation

intimate distance

personal distance

1 (0")
2 (6")
3 (1'0")
4 (1'6")
5 (2'0")
6 (2'8")
7 (3'4")
8 (4'0")

1 within body contact distance
2 just outside body contact distance
3 within easy touching distance with only forearm
4 just outside forearm distance (elbow room)
5 just touching or grasping distance with arms extended
6 just outside arm extended distance
7 within reaching distance
8 just outside reaching distance

Touching (tactile) Code & Notation

0 - caressing & holding
1 - feeling or caressing
2 - extended or prolonged holding
3 - holding
4 - spot touching (hand peck)
5 - Accidental touching
6 - No contact whatever

Eye Communication Notation

1 - sharp vision communication
2 - clear vision communication
3 - peripheral vision communication
4 - no visual contact whatever

Interaction Duration Scale

30 seconds (brief)
1 minute
5 minutes
longer

Apparent leader of Conversation

subject

participant

Apparent purpose of Conversation

business

personal

casual greeting

NB. The above notation systems are exact duplication of the Proxemic Notation System recommended by Dr Edward T. Hall professor of Anthropology and author of "The Silent Language" & "The Hidden Dimension"

Man communicates or interacts with his fellow man through use of his senses: sight, sound, taste, smell, touch, and the kinesthetic relationships mentioned above. It is imperative for any designer to understand the cultural and personal proxemic requirements of the people for whom he is developing a working or living environment if he intends to accomplish a compatible relationship between man and his environment and man to his fellow man in the environment.

The AMP clerk has specific sensory requirements in his everyday environment. These requirements were observed and documented through use of a data notation sheet.

The body orientation preferred by most AMP clerks during conversation or interaction is quite close and directly facing his conversant. 67% of the interactions took place with only 18" separating the conversants and 83% of the time the two were facing straight on (0^{o} - 90^{o}). Yet in 88% of the interactions, there was not any body contact or other tactile contact made between the conversants. In only 30 conversations of over 2,000 observed was intentional or accidental contact recorded. Similarly, it has been noticed that Australian businessmen seldom shake hands when they part company; and only during formal introductions will they shake hands when they are introduced.

In the office environment, 62% of all conversations take place when an individual is seated at his desk; while 38% of the conversations find the individual clerk standing. When a seated person initiates a conversation, he will select another seated person on 57% of the occasions; while standing clerks initiate 65% of their conversations with seated clerks.

When a standing person approaches a seated person to initiate a conversation, he will select a face to face orientation 71% of the time. Two standing clerks will enter into conversation facing one another 72% of the occasions; while two seated clerks will face each other only 56% of the time. In 64% of the conversations observed, both conversants used direct eye contact to reinforce communication. No visual contact was recorded in only 3% of the interactions observed.

Business conversations were conducted at closer range than social conversations, as 72% of the business conversations occurred within 18" 61% of the clerks interviewed complained of severe frustration with the odor produced by smokers in the office environment. 87% of the clerks questioned related that they had been bothered at some time by a fellow clerk's bad breath or body odor.

No mention was made of the noise level in the existing office environment. This unawareness was apparently due to the fact that people had resigned themselves to the noise that existed, suspecting that nothing could be done about it. Following the redesign of the Agency Accounts Department in which friendships were honored instead of denied, most clerks mentioned how much quieter the environment seemed. The office manager suggested that orientating close friends together and the carpeted aisles had substantially reduced the ambient noise level of the office environment to the satisfaction of everyone.

The translation of information from the social science investigation into usable jargon for the design procedure must also recognize the need of the client to comprehend and therefore be able to condone and participate in the process. A short lay-explanation of the three translation categories: sociability, territoriality and aggression prepares the designer and client to work at the same level with the information.

Aggression.

The aggression tendencies which motivate the AMP clerk in the daily ritual of his working routine are of two types. One is an individual aggression, in competition with his friends and neighbors, for personal recognition from his boss and fellow workmates; while the other is group aggression by his work section in response to an external stimulus. The external stimulus is usually a challenge provided by another work section to 'hurry up with the work' or an edict from the boss to 'do a better job'. The working section needs a close environmental identity in its working space to satisfy group aggression requirements.

Aggression is directed to social requirements as well as production requirements in the working environment. Seldom does a friendship exist that a third person is not aggressively trying to establish himself as a close mate of one or the other (generally not both) of the members of the friendship.

Some clerks are more aggressive than others and, subsequently, require more work and more interaction with others to satisfy their appetite for aggressive action. These persons would appreciate being located on a busy corridor or being given an extra job to do. Similarly, the less aggressive clerk would appreciate a location out of the action and independent of the competitive core of activity.

In each case, clerks who were tested and found to be aggressive agreed that they were dependent upon interactions with others and work challenges for the enjoyable part of their workday. Non-aggressive types, however, indicated that they were bothered to know that they were being watched. They further mentioned being approached from behind as a source of frustration; whereas, the aggressive type welcomed visitors from any direction.

Territoriality and Privacy.

The word territoriality is relevant in office design in reference to proper spacing and orientation of work stations or desks in order to protect against over-exploitation that part of the environment belonging to each clerk. It has been mentioned that individual requirements for privacy are the least considered element of design in existing office environments. This viewpoint is made in regard of a noticeably strong cultural requirement for territorial definition in the Australian society. With few exceptions, Australian house properties are fenced along their entire perimeter; in much the same way within the office environment, desks are considered 'private territory'.

The requirement for privacy from external noise and visual activity plague some clerks in their attempt to conduct their business routine. They use charts and equipment, such as typewriters, to define and protect their territory. Desk position and orientation to traffic aisles can improve or destroy private zones.

It appears that the strong cultural requirement for territorial definition would preclude open-space planning of office environments in the Australian working society. Many clerks, however, expressed potential satisfaction with delineation of small group territories, setting out work or social group entities within the department. 30% of the clerks tested and observed indicated a strong individual requirement for definition of their own territory.

Sociability.

The degree of sociability of an individual is the measurement of his special requirement for companionship. In the AMP clerk, this requirement usually exemplifies itself in the frequency and duration of interactions conducted by the subject. In many cases, however, the location of a person's desk, his tenure in the department or a required behavior demanded by management policy inhibits the ability of the individual to satisy his personal requirements for companionship. Age, or generation differentials are a common cause of communication breakdown, inhibiting satisfaction of social requirements.

As the status of the individual increases on the departmental hierarchy, he is expected to discipline his social appetite, limiting the number of his interactions to a recognizable level of acceptance. In one case observed in this research, a deputy manager of a department conducted frequent conversations of a social nature. The department is considered (by executives) to be one of the more efficient departments; and the manager confided in me that his assistant was 'well liked and received efficient work output from those under him'. "However,' he added, "I have had to warn him frequently that he is being too friendly with the staff'. Another departmental manager who was a sociable person related that he was 'just plain lonely' being isolated in his office. The frustration, resulting from his inability to satisfy his social requirement in his own department, led him to develop a schedule of regular visits to other departments during the working day. It was observed that clerks of section head status or above conducted 18% of their conversations for social reasons; whereas clerks of status below section head level conducted 38% social interactions.

The average duration of conversations varied widely in regard of the sociability of the individual and his status in the department. Section Heads consistently had a higher frequency of shorter conversations; whereas, the deputy manager and manager usually had few conversations lasting for longer periods than the average. In the clerk status, below section head level, the frequency and duration were directly proportional to a person's sociability.

In one remarkable instance, a young man and young lady sitting not too far from each other appeared to have an intense dislike for each other. They never exchanged conversation and even made extra effort to avoid joining into groups where the other was present. After observing this condition for 3 weeks the young man was questioned why he disliked the young lady so.....whereupon he blushed and explained that she was his grilfriend; and they did not want the management to think that their personal lives would interfere with their work routine.

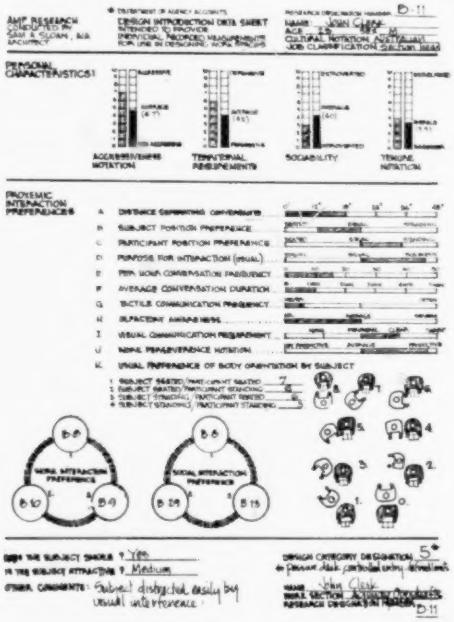
In each department observed and tested, there emerged a social leader who through extroverted social activity established herself as the 'pinnacle of action'. The repeatedly recognizable requirements for this position were physical attractiveness and an above average capacity of intellect. In one department, when asked with whom they would most like to converse 35% named the recognized social leader and another 30% named her most qualified competitor. Socially introverted or shy individuals, on the other hand, were often placed on a busy aisle or adjacent to the social extrovert thereby receiving an unwanted residual action from visitors. Several persons recognized to be 'unsociable' were questioned regarding this title. All defensively countered that they were not unsociable but readily admitted that they did not enjoy frequent conversations, nor did they appreciate people initiating conversations with them when they were trying to do an assigned task. It must be recognized that to be unsociable is not to be diseased; yet the conditions of an unsociable clerk's environment needs to be arranged quite differently than that of the department socialite.

Happiness.

The term happiness will appear many times in the contents of this report. Indeed, the very foundation of success of the case study is set out as being the degree of happiness of the clerk involved. An attempt to define the meaning of happiness to each individual clerk would require a lifetime. On the other hand, happiness is the one value accepted continually as a standard for a successful environment. It is quite common, when asked how an office or a building design has been accepted, to have the president or manager report, 'everyone seems happy with the design', in order to indicate his satisfaction.

Irrespective of the careful definition of happiness as the end product of the clerk's association with his workmates and his working environment, it must be assumed that reduction of the elements that cause frustration constitutes a more probable condition of happiness. In that regard, if an attempt is made to satisfy the personal and cultural requirements of each person as he lives and interacts with others within the boundary of his working environment, then the element of frustration should be substantially reduced; and the probability of happiness increased.

Stress is often caused by the requirement of a clerk to concentrate on his work while the consecutive interference of neighbors conversations and telephones make the task more difficult than it should be. A perfect example of this is the practice of placing the telephone on the desk of the person in charge of each section in order to mark his status in the group. His work requires more concentration due to his position; and the telephone impedes his ability to concentrate.



AMP RESEARCH
CONDUCTED BY
SAM A. SLOAN, AIA
ARCHITECT

DESIGN INTRODUCTION DATA SHEET
INTENDED TO PROVIDE
INDIVIDUAL RECORDED MEASUREMENTS
FOR USE IN DESIGNING WORK SPACES

NAME: John Clerk
AGE: 25 SEX: M
CULTURAL NOTATION: Australian
RESEARCH DESIGNATION NUMBER: D-11

PERSONAL CHARACTERISTICS:

PROXEMIC INTERACTION PREFERENCES:

A DISTANCE SEPARATING CONVERSANTS
B SUBJECT POSITION PREFERENCE
C PARTICIPANT POSITION PREFERENCE
D PURPOSE FOR INTERACTION (USUAL)
E PER HOUR CONVERSATION FREQUENCY
F AVERAGE CONVERSATION DURATION
G TACTILE COMMUNICATION FREQUENCY
H OLFACTORY AWARENESS
I VISUAL COMMUNICATION REQUIREMENT
J WORK PERSEVERENCE NOTATION
K VISUAL PREFERENCE OF BODY ORIENTATION BY SUBJECT

1 SUBJECT SEATED/PARTICIPANT SEATED 7
2 SUBJECT SEATED/PARTICIPANT STANDING 8
3 SUBJECT STANDING/PARTICIPANT SEATED 6
4 SUBJECT STANDING/PARTICIPANT STANDING 5

DOES THE SUBJECT SMOKE ? Yes
IS THE SUBJECT ATTRACTIVE ? Medium
OTHER COMMENTS: Subject distracted easily by visual interference

DESIGN CATEGORY DESIGNATION 5*
NAME: John Clerk
RESEARCH DESIGNATION NUMBER: D-11

Relevance of Personal Data in Making Decisions.

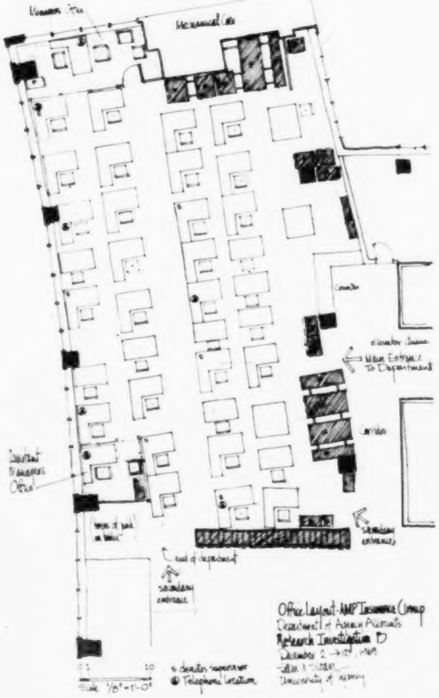
The actual design time spent arranging scale model chairs and desks into work and social groups in relationship to individual and group requirements was less than six hours. The information data sheets worked like a game of dominoes with the individual sociograms of work and social preferences dictating the groupings within the work sections as well as overall group placement of clerks in the department. Delineation of spaces through use of semi-fixed (movable) features, such as files, as well as requirements for individual spatial definition were easily accomplished through use of the territorial requirement scale. In matters of design compromise, tenure dictated first consideration.

The translation from personal-characteristic-requirements to spatial-requirements was a necessary first step. It developed the flexibility of a categorical system necessary to meet changing staff conditions. Clarification of requirements into spatial language also helped in determining the general environmental requirements that a designer can attempt to satisfy in terms that a designer can understand. Briefly, the clarification was:

1. Sociability determined an active or passive environment for the occupant. More socially orientated clerks received more active environments.

2. Aggression documented the tolerance limits of the invitation by the occupant to others in the department to participate in conversations. Unaggressive clerks were given secluded entries; whereas aggressive clerks who were unsociable were given a controlled entry. Aggressive and sociable clerks were given an open entry.

3. Territorially concerned people were given work spaces that were well defined in the limits of their ownership of space; whereas those who indicated less than an average territorial requirement in many cases had their desk contiguous to their neighbor and shared work layout space.


Managers Office
Mechanical Core
Corridor
Elevator Lobby
Main Entrance To Department
Corridor
Secondary entrance
Assistant Managers Office
end of department
Secondary entrance
Office Layout-AMP Insurance Group
Department of Annuity Accounts
Research Investigation D
December 2 → 12th, 1969
University of Sydney
0 5 10
Scale 1/8"-1'-0"
denotes supervisor
Telephone location

When the office design layout had been completed, each desk was then considered carefully in regard of the potential distances and orientation of participants. The information of preferences for interaction relationships, compiled from the proxemic observation sheet, was considered for every clerk. People registering severe frustration with smokers were reconsidered as to their proximity in relationship to those who smoked.

The design was reviewed with the manager who suggested a minor change in filing cabinet location. The clerks of the department were asked to comment critically on the design and voiced approval of the scheme.

This case study made it readily obvious that the designer of a departmental environment, was temporarily assuming the role of the manager. The decisions that predicate environment design of a grouping of clerks in relationship to a work task are the decisions that a manager of the department must make each time the work task alters, or the clerical staff alters.

Conclusions:

The translation of social science data using sociability, territoriality and aggression as categorical considerations worked satisfactorily. This particular study revealed eight categories (a numerical extension of 3 variables) each equally represented amongst the 97 clerical samples.

Personal Characteristics

C1 sociable, aggressive, territorial

C2 sociable, unaggressive, territorial

C3 sociable, unaggressive, non-territorial

C4 sociable, aggressive, non-territorial

C5 unsociable, aggressive, territorial

C6 unsociable, unaggressive, territorial

C7 unsociable, unaggressive, non-territorial

C8 unsociable, aggressive, non-territorial

Environmental Requirements

C1 active desk, controlled entry, defined limits

C2 active desk, secluded entry, defined limits

C3 active desk, secluded entry, undefined limits

C4 active desk, open entry, undefined limits

C5 passive desk, controlled entry, defined limits

C6 passive desk, secluded entry, defined limits

C7 passive desk, secluded entry, undefined limits

C8 passive desk, controlled entry, undefined limits

Designing within the developed categorical requirements, cloth fabric panels were suspended from the ceiling to break the open space of the department into smaller entities of space relating to work groups and social enclaves. Persons requiring higher degrees of territorial definition were given perimeter walls, filing cabinets and the hanging fabrics to define their spaces. The main corridor was carpeted to create a change of floor texture and therein definition of the aisle as a public zone. Secondary aisles were developed within the desk arrangements in accordance with the entry requirements of each individual clerk. Zones were established where the action would take place and socially extroverted clerks were grouped in the active zones. Filing cabinets were arranged in an effort to discourage interaction; and privacy was developed in perimeter zones for the passive, less sociable and territorially orientated clerks.

The distance, relationships and orientation of each desk to its adjacent desks and entrance patterns were then carefully considered in 'fine-tuning' each desk in accordance with the proxemic requirements of individual clerks. A public-use room was arranged in the corner, maximizing the view potential of Sydney Harbor.

All noisy equipment was located in the room along with a public telephone to be used for social calls. Clerks are encouraged to spend some portion of their working day in this change-of-environment', providing the department has not exercised priority use of the space as a meeting room.

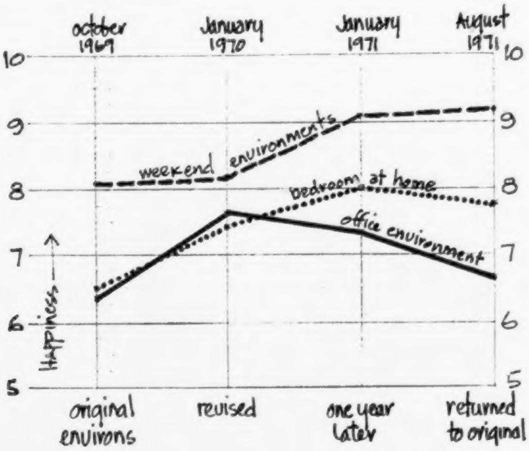
A final, and most necessary, gesture on the part of the designer was to provide the clerk with a 'users manual' of instructions carefully prepared by the management and the architect on how it is intended that the elements of the design be used.

Post-revision Observation and Analysis.

The utilization of social-science criteria programming was successful in eliminating the long and tedious 'trial and error' method of desk arrangement. Paying particular attention to the active or passive orientation of personalities and the sociometrys of social and work group preferences, the process was little more taxing than a good rousing game of 'solitare'.

The Agency Accounts Department which was chosen for the remodel is a middleman in the Australian Mutual Provident Society.....that is to say the department receives work from one department and passes it on to another. Their rate of work output is therefore regulated by others. However, the overtime factor was reduced during the year of occupancy and normal increases in personal were not necessary indicating an approximate increase in work output of 15 - 20%.

A very simple line-bar happiness test asking clerks to draw a line on a lineal graph measuring 0 to 10 until a point was reached which corresponds to their evaluation of the happiness coincidental with that activity has produced an interesting pattern.



The main point to recognize is that the 'Hawthorne effect" is not at work in this case study. The measured increase in satisfaction with the carefully contrived development of space relationships is due to social and psychological programming at the outset of the design process and careful utilization of the criteria in the decision process.

The method is re-usable to any people-oriented environment and will benefit a great deal from the utilization of a social-psychologist. The data gathering techniques are a direct usage of Bob Sommers', Dr. Edward T. Halls' work and some simple one-line/response questions from several other sources. The results were suprisingly accurate when tested by sharing them first with management and then with the clerks themselves. The evaluation of each clerks personality was disputed in only 2 cases of 97.

When the clerical workforce of the Agency Accounts Department was first interviewed, 61% of the people desired a change in their working environment. Following the remodel of their space, only 24% indicated a desire to occupy another choice of desk environment. After occupying the remodeled office for over a year, 31% indicated that they desired a change. When the desk arrangement was returned to the original layout 1½ years following the initiation of this case study, the dissatisfaction level increased to 50%.

A girlfriend enters into conversation through a carefully prepared slot in the fence defining the territory (it took 8 years to build)......

A third party enters by greeting the initial visitor and then positions himself to control the territory of the seated--owner of the space

15: SPECIAL GROUP NEEDS

AGE GROUP NEEDS AND THEIR SATISFACTION
A CASE STUDY OF THE EAST LIBERTY RENEWAL AREA, PITTSBURGH

Gwen Bell and Margrit Kennedy with Nancy Mason, Bea Ornitz, Sue Ellen Semple and Marcia Thompson

Associate Professor and Graduate Students
Department of Urban Affairs
Graduate School of Public and International Affairs
University of Pittsburgh
Pittsburgh, Pennsylvania 15213

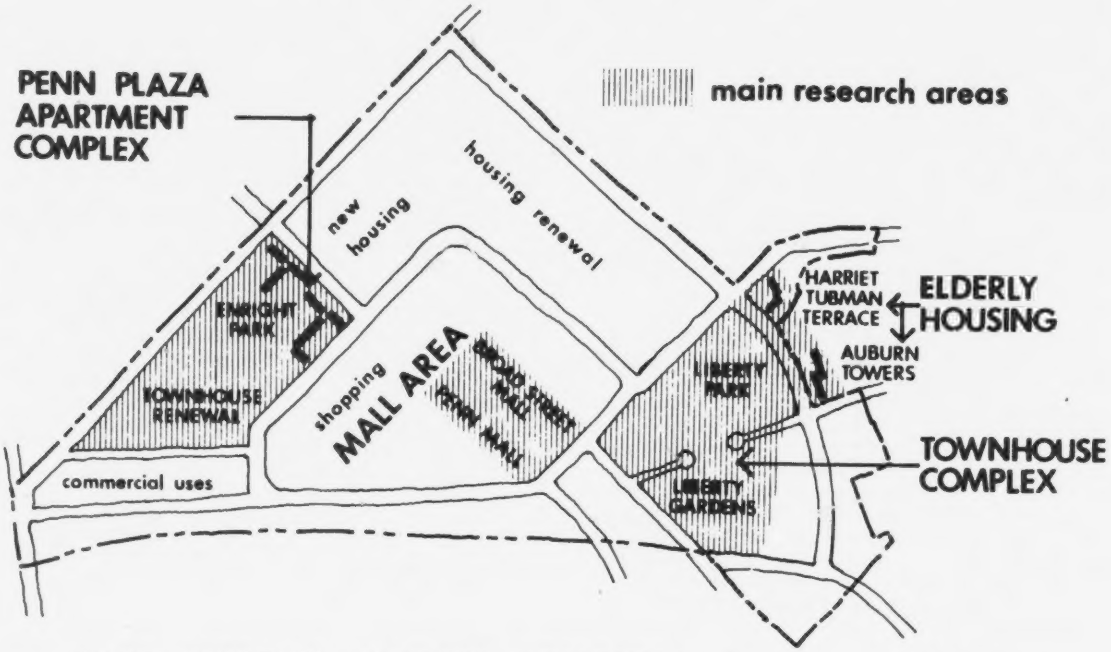
East Liberty is one of the largest Title I renewal projects in the nation. It comprises 254 acres of diverse commercial, residential, institutional and recreational uses. Over 600 of the 1,105 dwelling units existing prior to renewal were rehabilitated and 26 business properties renovated. (Fig. 1)

Despite the fact that 130 acres -- or over one-half of the project area -- were rehabilitated, the renewal of East Liberty has created an almost totally "new" community environment. The street pattern and traffic system has been almost entirely redesigned with 2,000 publicly-built off-street parking spaces to serve the commercial district alone.

The structure and density of the new housing and commercial establishments now dominate the landscape.

With a project involving this scale of physical change it is necessary to ask: Does such an environment meet the social needs of local residents in the public space provided? And, how might the design of these components be changed to meet the observed needs.

During March, 1971, controlled observations were made and records kept of the location of activity in the Mall and residential areas, 30 residents of the housing for the elderly and 30 elderly 'habitues' of the Mall were


PENN PLAZA
APARTMENT
COMPLEX
main research areas
new housing
housing renewal
ENRIGHT PARK
TOWNHOUSE RENEWAL
commercial uses
shopping
MALL AREA
BROAD STREET MALL
PENN MALL
HARRIET
TUBMAN
TERRACE
ELDERLY
HOUSING
AUBURN
TOWERS
LIBERTY PARK
LIBERTY GARDENS
TOWNHOUSE
COMPLEX

EAST LIBERTY URBAN RENEWAL AREA FIGURE 1 interviewed, and programmed discussions were held with teenagers attending the nearby high-school. In all cases, focus was on utilization of the public spaces in East Liberty.

Residential Areas

Adults and Children. Liberty Gardens and Liberty Park are two similar relatively dense townhouse complexes with small intimate spaces between the rows of houses and different clusters. They also include several eight- to ten-storey apartment buildings. Penn Plaza consists of several four-storey apartment buildings with a rather large landscaped area (Enright Park) between them.

The only outside areas designated for socializing in both projects were childrens' play-grounds. They are of the usual "asphalt-swing-climbing arch" variety except for one old steam roller engine in Enright Park and a few sculptures.

Enright Park generally has the better facilities but was used only a little more intensively than the smaller and more dispersed tot lots among the townhouses. While Enright Park has the disadvantage that it is too far from either the apartment buildings or rehabilitated townhouses for children to safely visit on their own, the playgrounds near the townhouse clusters are too simplistic and too uninteresting for the children to use continually. During the observation periods, children spent three-quarters of their time playing elsewhere; on hillsides, in parking lots, between garbage cans, and especially on the paths and path-junctions.

In Penn Plaza use was made of the varied topography. Each playground was placed on a different level and differentiated paths connect them imaginatively. Adults and children alike seemed to find great pleasure in being led the longest possible way from one place to the other.

The basketball court with several backstops is probably the most successful feature of Enright Park. It is a socialization focal point for teenagers from the neighbourhood, and attracts blacks and whites, boys and girls, players and non-players alike. The tennis court next to the basketball court was never used as such. There was no net and no club or changing facilities to attract players. Instead children use it for riding bicycles or playing tag. It has potential to serve this age group much better, for example with a neighbourhood self-help youth club or a supervised adventure playground.

The place where most of the informal outside socializing was observed was the *parking area*. Adults met there on their way between parking their car and going to their homes: they mend cars in their free time; children and teen-agers meet here, riding bicycles or tricycles, playing ballgames, chatting and sitting on or leaning against cars.

In both projects there is some attempt to provide more than just asphalt. Several small trees were planted (and barely survive under the load of children climbing and swinging on them) and some parking areas have small landscaped strips in the middle. But once cars are parked in front of these strips the miniature paths and hills completely disappear behind them and the landscaped parking area looks as drab as any other. Four or five mature trees instead would have been cheaper and more useful.

If one accepts this pattern of informal socializing in or along the way to the parking areas, something more than the provision of trees seems necessary. Either the lots should be small enough not to intrude, limited to a small number of cars,or sizeable landscaping should be invested in between or near parking lots with benches and some kind of shelter for shorter or longer intervals of carrying on outdoor activities.

In comparing the behavior settings of traditional housing areas within Pittsburgh, no substitute was found for the traditional *open front porch*. This space between the private and public realm is absolutely essential for purposes of casual socializing with neighbors, as a setting for quiet play, and storage for outdoor clothes and equipment. Where socializing does not occur because of the lack of any such provision the behavior cannot be interpreted as "incongruent with design" rather it could be said that "the design is incongruent with otherwise usual behavior"-- or lack of consideration in the design for social interaction results in greatly impoverished social life. A few of the houses in Liberty Gardens--Liberty Park had something like a reminder of the open porch idea; a recessed entrance area. Their importance was noted as every time observations were recorded these recesses were in use by adults or children. Additionally, in front of entrances that had no recess or porch, children built very neatly defined areas to play and sit outside. The adults, in contrast, were seen sitting behind windows, leaning out of windows and chatting across the way or sitting behind their glass entrance door to look out and take part in what was happening.

The Elderly. Though loneliness seems to be a universal problem which elderly persons face, it can be enlarged, forced or lessened by design, planning and organization. In two housing projects for the elderly the problems were manifested in different ways.

Harriet Tubman Terrace, a building entirely designed to facilitate handicapped persons, contains 56 subsidized units in two 3-4 storey wings with central corridors stretching out from a fairly large hall between the two wings. Auburn Towers, a public housing complex, accomodates 376 persons in 294 units. It has only a small hall with stairway and elevators but has open gangways leading to the individual units. (Fig. 2) These open gangways fulfill a similar function to the open porch for the single family or townhouse. The elderly person can sit in the livingroom which opens directly onto the gangway, look outside and watch others coming and going. Neighbors can stop and chat for a while without having to be invited to come inside. This frequent informal socializing has no counterpart in Harriet Tubman Terrace, where the orientation of the livingroom is to the outside only and not to a common corridor. Central corridors do not have the potential for socialization which is in conflict with maintaining "quiet".

The inhabitants of Harriet Tubman Terrace complained about the lack of organized recreational activities. The common clubroom was hardly ever used and the activities in the nearby Auburn Towers was hard to reach because of the steep path leading up to the larger complex and of the anxiety of returning in the dark, with scarce lights along the way and no handrail for security.

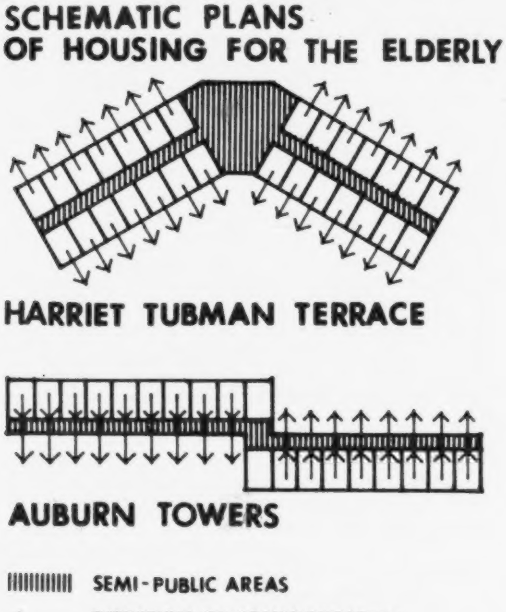

SCHEMATIC PLANS
OF HOUSING FOR THE ELDERLY
HARRIET TUBMAN TERRACE
AUBURN TOWERS
SEMI-PUBLIC AREAS
DIRECTION OF COMMUNICATION WITH OUTSIDE WORLD

FIGURE 2

Auburn Towers had a number of organized ongoing recreational facilities and sufficient room for it, but here people felt lonely because the complex itself is too large in size and numbers of inhabitants. While the amount and variety of organized activity depends on the amount of people involved, and 56 units certainly will not yield a large enough number to facilitate any kind of choice in a recreational program; this does not mean that one has to go to the other extreme of piling 300 units on top of each other to provide economically feasible community facilities. To achieve this ideally the overall number of persons should be large enough but has to be broken down into smaller units which allow some identification with the environment as well as personal contacts. Centralized community services can then be within easy and safe reach of each person and complement not substitute informal meeting and gathering opportunities.

Outside sitting areas were used frequently, mainly the ones that faced "the action," traffic or main pedestrian thoroughfares. The only problem was that the benches were backless, and too uncomfortable to sit on for a longer period of time, so that people were forced to bring their own chairs.

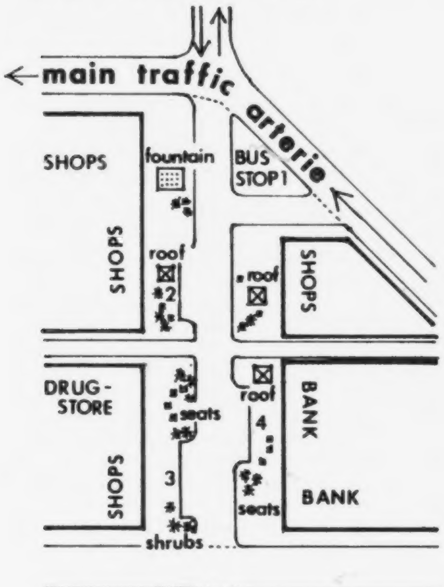
The Shopping Malls. The East Liberty Shopping Malls comprise both old and new shops and alternating system of service roads and shopping malls, which are partly pedestrian and partly open to cars and buses.

Activity Levels in various parts of the Mall are very different. The most striking distinction in this respect exists between Penn Mall and Broad Street Mall.

Penn Mall is a very lively area. Three major bus stops generate crowds of waiting people mainly around the late afternoon peak hours. Here peddlers sell wigs, books, or candy; and young and old sit on the low wall of the fountain or on street furniture and mix with the waiting crowds to enjoy the sun and action going on. (Fig. 3)

Compared to the life and happenings on this mall, Broad Street Mall, the next parallel shopping area to the north, is desolated and empty. Nobody uses the street furniture which is a duplicate of that on Penn Mall. Few peo-

BUS STOPS AND WAITING AREAS ALONG PENN MALL



BUS STOP 1 SURROUNDED BY TRAFFIC.
BUS STOP 2, 3, 4 : SHELTER, SEATS, AND SHRUBS.

FIGURE 3

ple stop to look at the shop windows while they pass. None of the elderly who used restaurants and snack bars on both malls used the outside areas in front of those establishments on the Broad Street Mall while on the Penn Mall they were constantly used for the purpose of socializing.

Generally then it can be said that people will go to socialize where people are. It therefore is of utmost importance to locate activity generators, such as bus stops, drugstores, or department stores in such a way that they will be near places designed for socialization and recreation. This rule has been applied inconsistently in the East Liberty Mall area, and the failures can be traced easily.

One main bus stop, for instance, is situated in a small triangular piece of land in the middle of three intersecting roads, one of them being a main traffic artery with heavy truck traffic. Nothing protects those waiting from the exhaust fumes, noise and inherent danger of standing in the middle of the traffic. Behavior and facial expressions of those waiting here are worth comparing with those waiting further along "inside" the mall area where shrubs, seats, and small roofed areas create pleasant waiting places. In the first situation most of the people look somewhat tense and annoyed while in the second people feel more at ease, frequently they talk to each other and allow children to take off and play around on their own.

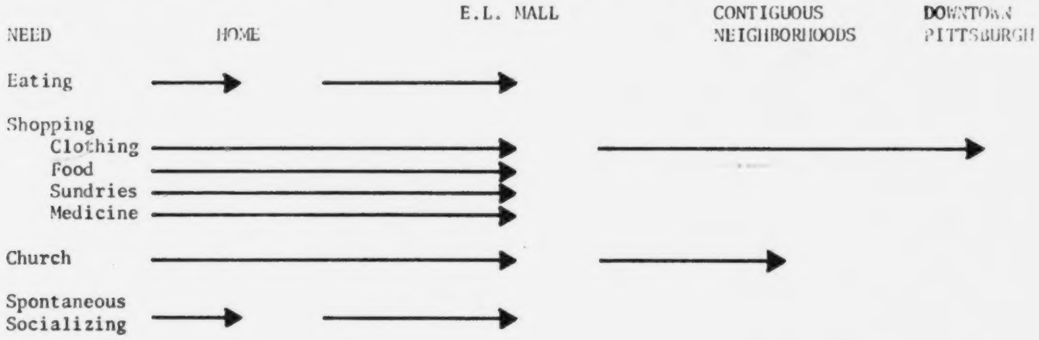
In differentiating seating areas low walls to protect benches give a sense of enclosure which is in keeping with the scale of sitting. However, if such protected benches are sited facing a building of low activity people will rarely use them. This is the case in a protected area facing a monumental church with its back to the shopping side of the street. All in all the unfortunate design solution creates a "hole" in the otherwise continuous flow of activity and lessens the attractiveness of the pedestrianized side-wall around the back of the church.

Implications of this study also suggest that there is a necessity for public indoor spaces which might more successfully enhance social opportunities especially for the elderly and teenagers, who are similar in devoting significant amounts of time to "passing the time of day" in a Mall. A socio-economic class and age cohort stratification is evidenced in the preferred places of different groups. Some places, mainly the older and renewed ones have strong symbolic connotations for older residents of the community. The vernacular atmosphere of older establishments within such a dramatically redesigned area is clearly a magnet to the elderly, while teenagers which constitute a much smaller and more transient group of users, prefer the new and even cheaper hot dog and hamburger places, and throng to the mall for special outdoor events.

The elderly preferred to use the Mall facilities for eating, shopping and spontaneous socializing, in fact it was the locus for most of their activity. Environmental and locational criteria for measuring the "preferedness" of the designated facilities showed that price factors range first, then security and attitude of management, density of activity, physical amenities and degree of spontaneous socializing. (Fig. 4)

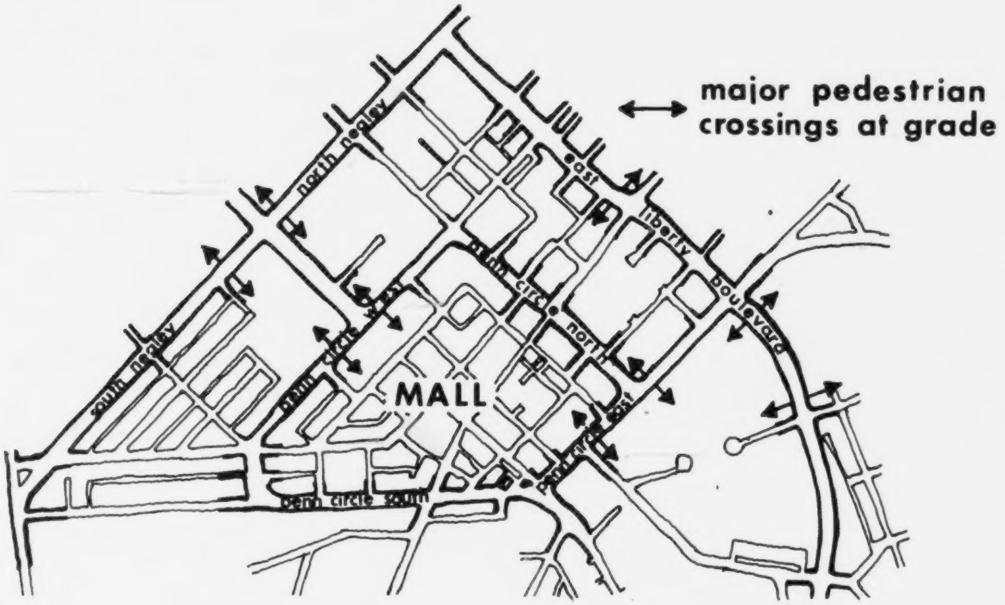
Most elderly persons are strongly motivated by a desire for social interaction outside of their home setting. This is especially true for men who are distinctly more route oriented than their female age cohorts, whose continued household activity makes them more destination oriented. Both, nevertheless, preferred areas of high activity for spontaneous socializing, inside or outside.

GEOGRAPHIC RANGE OF NEED SATISFACTION FIGURE 4



Pedestrian Paths Throughout the Area. The first fact that strikes the new-comer (who knows about the enormous amounts of money and planning that have gone into this renewal project) when he enters East Liberty by car or bus or foot is the "half-separation" of pedestrians from auto traffic. The alternating system of service roads and pedestrian malls becomes entirely confusing because there are pedestrian malls along which vehicular traffic is allowed and service lanes that act as pedestrain links.

If one does not accidentally take the two or three minor points of vehicular entry into the maze of roads open to automobile traffic, it is virtually impossible to figure out how cars get into the project in the beginning. It also is quite unclear where the pedestrain only has the right of way. This in itself creates a constant uncertainty of how little or how much care one has to give not to be run over by a car. In some parts, cars (in the Mall) move extremely slowly; in others, they whip around corners


major pedestrian crossings at grade
north negley
south negley
east liberty boulevard
penn circle north
penn circle west
penn circle east
penn circle south
MALL

EAST LIBERTY URBAN RENEWAL AREA FIGURE 5

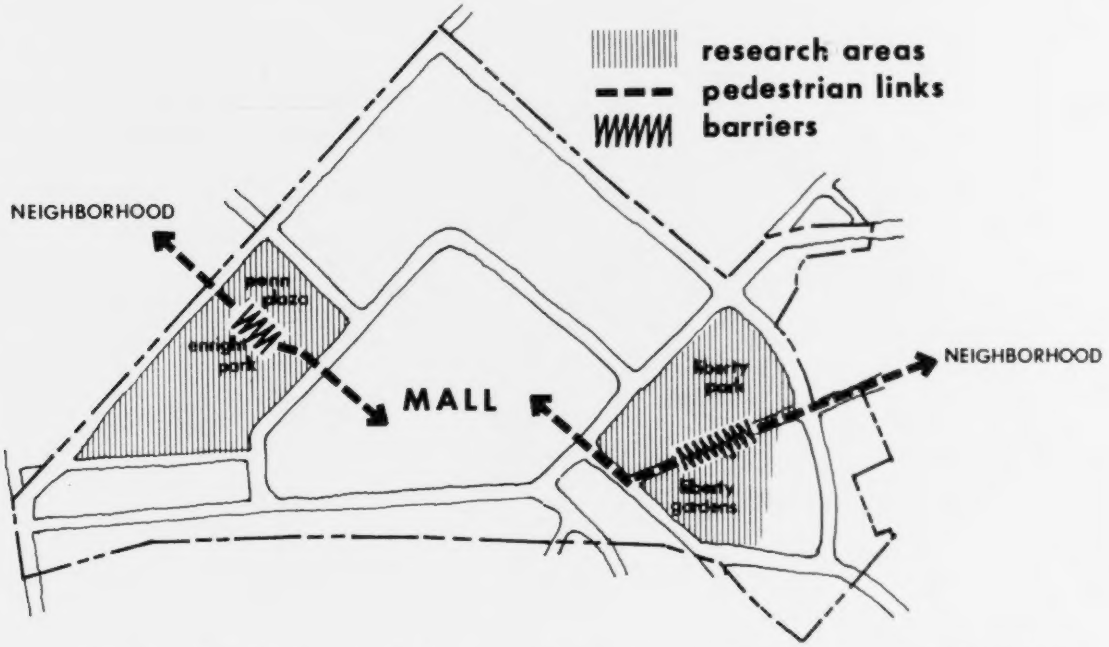
with considerable speed. But the most incredible traffic design failure is the double ring of four-lane highways in and around the renewal area (see Fig. 5) which all have to be crossed by the pedestrian at grade. The fact that even school children cannot reach their primary schools without crossing major traffic arteries reminds of the darkest "pre-Buchanan" times. As in most cases the weakest, namely children and elderly, suffer the greatest from this arrangement. Our research shows that children are in constant danger crossing roads on their way to and from schools, because they often try "to make it" even if the lights have changed to yellow already; while the elderly, most of whom are handicapped in some way or other cannot reach the other side of the road in the time of one light-change. This danger restricts the mobility of just those people who enjoy a walk to the shops where there is activity. (Fig. 6)

There are several possible solutions to the problem in general: (1) separated grades, under or over paths; (2) ring of roads large enough to encompass neighborhood and only service roads or cul-de-sacs leading into the center, which includes a primary school within the center or neighborhood as well as housing for the elderly; (3) a sufficient adequate and city-wide public transport system which would greatly decrease the need and capactiy of roads and parking areas.

In mapping the most frequented pedestrain routes in the residential areas Liberty-Gardens-Liberty Park we found that the children's wandering about mostly took a circular route. They were cutting across grass and mud areas, hills and semi-private or private gardens if they were not properly fenced in. This movement of whole groups of children naturally will become quite detrimental to any landscaping effort. But instead of starting to put up fences in order to save grassed areas or hillsides, it would do more for children and parents to accept this urge of roaming about and to pave those areas that have proved to be the most attractive. To prevent children intruding on the privacy of gardens and courts it may be enough to plant some thorny bushes which will certainly help the appearance of the area more than a wire fence.

It would be false to assume that only children will ruin a landscaped area by short-cutting or following their favorite route. But adults also take the shortest route to destinations.

Main pedestrian routes from neighboring communities to the Mall area through the Penn Plaza complex as well as Liberty Gardens-Liberty Park were not planned as such. The route through Penn Plaza Project goes right through the middle of the basketball--tennis court and then



EAST LIBERTY URBAN RENEWAL AREA FIGURE 6 through a parking lot (besides crossing two major traffic arteries). The route through Liberty Gardens-Liberty Park crosses about 100 feet of unpaved open field which serves as a garbage and litter dump without any lighting. Mainly in the winter where sizeable puddles and stretches of ice develop and darkness sets in early elderly from the housing projects across the street have a hard time crossing this part.

Quite certainly both routes have never been envisaged to take the amount of pedestrian traffic that occurs according to our observations. Sidewalks next to the roads were meant to be used, although they were not constructed until after the housing was completed. But by the time our observations were completed, the route through Enright Park had become a permanent pattern, as it surely proved to be a relatively more pleasant walk than next to the heavy vehicular traffic of Penn Avenue.

General Conclusions

This research into the behavior patterns and utilization of open spaces by different age groups in the East Liberty Renewal Area proves that many uses can be foreseen by the planner and incorporated into his design. But there will always be some particular circumstances, special places or particular ways of behavior that develop after the project has been given over to the user. It may well be that exactly those patterns which develop during the use are the ones that determine whether the project is successful or not. It is therefore of the most vital importance to set aside in the budget funding for a feed-back study and "post feed-back action ". Any feed-back study alone is utterly useless if nothing can be rectified (because funds have been overdrawn several times already). Compared to what has to be originally spent to build the project, "post feed-back action" should usually turn out to be negligible, little but the effect may be enormous. A small recreational program, some street lights, several trees, paving 100 feet of pedestrian path or providing a handrail may decide whether millions of dollars worth of "renewal" will be used to its full capacity or not. This may also provide a focus for community participation which often is sadly lacking at the outset of new renewal areas.

The effect of major mistakes can only be made bearable not reversed, e.g., the lack of porches; road layout; the combination and type of shops or housing; too many or too few elderly in one building complex. A feedback study in this respect can only hope to influence what is to come.

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A COMPUTER-AIDED PROCEDURE FOR DESIGN OF ENVIRONMENTS FOR THE AGED

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Traditionally, the old folks home has been viewed as an institution with a minimum of food and shelter for the body and an abundance of hymns for the soul. (1) Now that the aged have gained longer lives as a result of scientific and social welfare advances in this century, they have become more vulnerable to the problem of the isolation that comes with aging. There has been a net yearly increase of four hundred thousand persons over sixty-five since 1900, and the number of persons over eighty-five has increased nearly one-hundred per cent. (2) Mass mobilization and growth in urban population will continue to push the aged out of their past roles as members of three-generation families and into geriatric institutions. These members of geriatric institutions not only come from diverse backgrounds, but they are less adaptable in assuming new social roles. They have generally established particular living patterns which have crystalized over the years. (3)

Designers often fail to remember when establishing criteria for housing old people that they have only age, and a variety of physical infirmities in common. The elderly are too often treated as a homogeneous group who lack the capacity to generate group dynamics essential to social interaction. Architects have long censured profiteering corporations for building visually unimaginative institutions for the elderly and for ignoring their spatial needs. Building where land is cheapest,entrepreneurs have, indeed, denied the aged the possibility of pedestrian urban activity. The aged have perhaps suffered as much from the "good intentions" of high fashion architects. With the exception of Robert Venturi's Guild House in Philadelphia, most celebrated designs have not accommodated the living patterns the elderly bring with them to geriatric institutions. Instead many architects seem to favor heroic monuments and expensive materials in order to give a community symbol which pleases city administrators. These monuments then inspire other architects to follow suit.

The resident of a geriatric home usually battles with family, financial setbacks, and physical infirmity until he is forced to rely upon institutional care. This may range from a senior citizens apartment group to the full-time care geriatric hospital. Irving Goffman has said that if he is not acutely ill when he enters a long-term care facility, a patient reacts aggressively against institutional severity. Interviews and observations which I have conducted in long-term care homes have shown that rational reactions to institutional care continually decrease over time until patients cease to verbalize their dissatisfactions. What would cause this final lack of reaction?

In working with elderly groups in New York the Manhatten Society for Mental Health found that aged persons associated happiness with periods of anticipation or involvement with at least one other person. (4) The communicative older person has behavioral characteristics as diverse and as common as all gregarious men. Because he or she is the essential ingredient of any housing environment for the elderly, this environment needs to allow for some of the flexibility of behavior which existed outside the geriatric home. An aged person can become a caricature of his former self as dominant personality traits surface and become fixed with aging.If the long-term care facility inhibits the behavioral tendencies of old people, little attempt may be made on their part to adapt to this new environment. Withdrawal is the immediate line of defense. In ceasing to digest the external stimuli which do exist, an elderly person begins to enter a disengagement syndrome in which he suppresses responses through which his personality is normally expressed. This is the appropriate reaction when one considers the new life-space of the institutionalized aged. Irving Goffman describes the introduction into institutionalized life:

> "Like the Neophyte in many total institutions, the new patient finds himself cleanly stripped of many of his accustomed affirmations, satisfactions, and defenses, and is subject to a rather full set of mortifying experiences: restriction of free movement, communal living, and to diffuse authority of a whole echelon of people. Here one begins to learn about the limited extent to which a conception of oneself can be sustained when the usual setting of supports for it are removed." (5)

Once this adjustment has taken place, old peo-

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ple may cease to discuss present as well as past experiences and only communicate physical ailments. I have found this true in all long-term care institutions that I have observed. Social interaction and personal space encourage the individual to develop a self conception which will regulate his way of defining social situations with reference to himself. The resident must usually give up personal property which might have been used for self identification to others. If an individual perceives himself partly by adopting as his own the attributes others express towards him, then the preservation of the self depends upon a kind of social communication which the older person is able to control.

I believe that it is the denial of even the possibility of private space in the geriatric home which forces the aged resident to resist social exposure. Patients rooms are typically crowded and undersized even in the most modern geriatric homes. Nursing staffs in homes I have visited seem to agree that the hostility between patients is directly proportional to the number of residents per room.

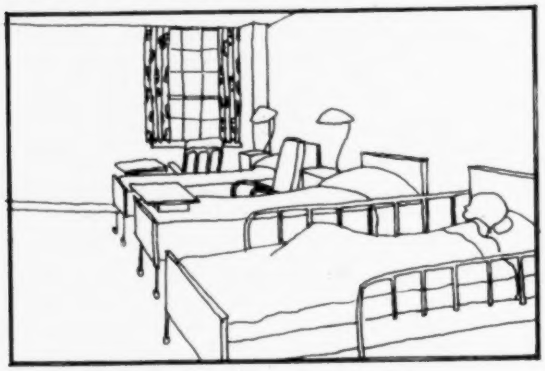

Figure 1.

Motivated by profit, or ostensibly by promoting social interaction among residents, planners of geriatric facilities have provided public rooms for group activity of twenty persons or more while they have omitted the possibility for private activity.(Figure **2**) Examples presented herein were drawn from photographs taken at Heritage House, a very clean and modern long-term care geriatric home in New Haven, Connecticut. Heritage House is part of a nation-wide chain. Here each phase of a patient's daily activity must be performed in the immediate company of at least two other people, and all residents are usually required to participate as scheduled.

In the interviews documented by the Manhattan Society for Mental Health the aged stressed the need for human beings at every age to have privacy.

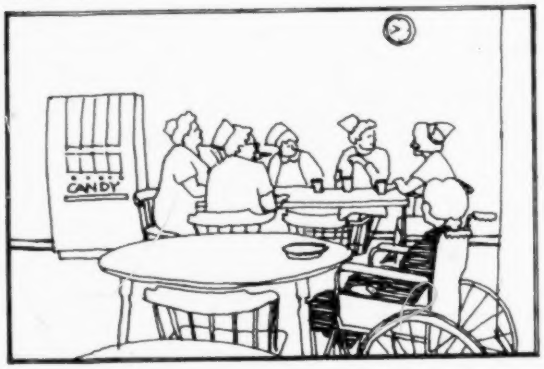

Figure 2.

They equated a lack of dignity with a lack of privacy. (6) The individual's need for personal space must be recognized in the physical arrangement of the geriatric environment, or he reacts by seeking out isolated corners where he may separate himself from his fellow inmates in order to obtain privacy and control of his space.

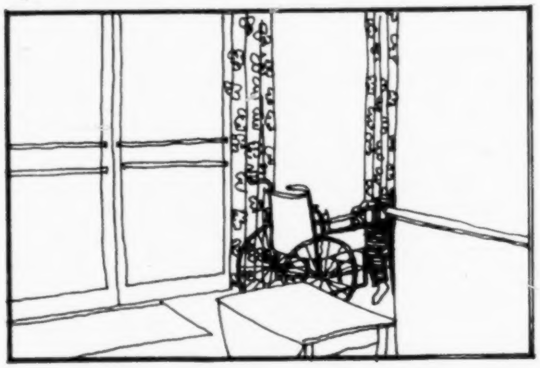

Figure 3.

Because he does not have interests common to all other occupants, the patient will choose only a few people with whom he may wish to have intimate contact as would any human being in any age group. Where can this small-group interaction take place? In a bedroom shared with three other patients? In a T.V. room which seats thirty-five persons? Other options usually do not exist.

Serge Chermayeff suggests in his studies of urban theory that we must aim for maximization of choice for all individuals. This can be achieved by preserving the integrity of complementary opposites in a spectrum of organized choice. Certainly this theory should be applied to the institutional situation as well as to urban design. Perceptible diversity is as necessary for the continued activity of the elderly as it is for the developing minds of children. Spatially, the geriatric home must contribute to organized choice rather than to undifferentiated spaces, each unable to accommodate its own particular form of social interaction. Social interaction will not occur without an elimination of constant intrusion into every activity of the resident. Having observed many communal rooms in many geriatric homes, I have consistently found that residents rarely engage in continuous conversation in groups of two or four people. Patients are arranged in long rows of chairs for efficiency in cleaning communal spaces. Privacy is attempted by creating unencroachable territories in the mind.

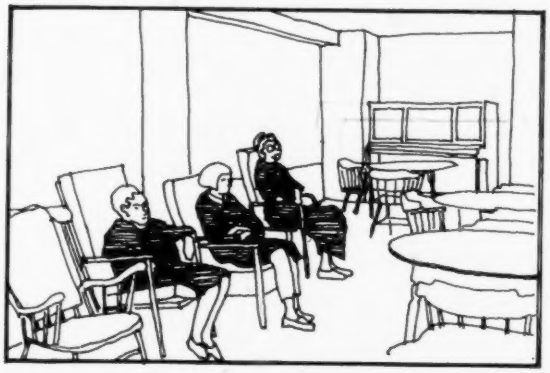

Figure 4.

Because an institution can physically become a bounded environment, individual territorial demands must be accommodated. The small scale of the environment offers far less opportunity for securing personal space than does the outside world. Though ambulatory patients may be encouraged to take their meals in a dining room, many refuse to leave their beds in the early morning. They may wander aimlessly, once they are out of their bedrooms. At Heritage House, nurses begin checking all rooms to force patients out of bed. Social interaction generated through self-determination did not exist.

The elderly have little capacity for action against a hostile environment. Furthermore, the necessity for privacy is possibly not directly as apparent to them as their more immediate physical needs. Who, then, will argue the case for the resident of the geriatric home? He is easy to suppress, since his retaliation poses no economic threat to the builder of the home. The designer himself may be unaware of the social situation he has created because of this denial of privacy.

Exclusion of communal spaces for public and semi-private social gatherings in favor of only private space would deny the possibility of person to person confrontation. A full spectrum of space must be provided. If this is the case, then perhaps the computer could become an advocate for the elderly or any other powerless minority. As an advocate, the computer should point out weaknesses in design solutions not ordinarily examined by the designer or the builder. For each social minority there is probably some area of design parameters often overlooked, since efficiency of the design is usually measured in terms of overt functional or economic performance. Of course, architectural programing unsupported by proper social programing cannot begin to resolve social issues.

Olden is a fairly uncomplicated computerized game which can be used to enlighten the designer about the success of his design proposals in providing a framework for social interaction in geriatric institutions. Since profit motivation focuses concern for economic efficiency, measure for success in this area is not included in the program. While the interactive portion of Olden asks questions having spatial implications, Olden does not produce graphic output.

Olden is composed of a set of subprograms which are listed as follows:

1. An interactive portion which questions the designer about the spatial configuration of the institution.
2. A listing of all the spatial elements of possible design solutions.
3. A square incompatibility matrix reflecting the decisions of the designer and intrinsically incompatible spatial elements.
4. A morphological variety/reduction algorithm which reads the incompatibility matrix to produce possible solutions dependent upon the designers responses.
5. A scoring procedure which grades each solution generated for its success in offering maximization of opposites of community and privacy. One might also view the evaluation as a measure of the possibility of choice for social interaction along a broad spectrum.

Behind the interactive face of the game is a highly structured and perhaps restrictive listing of the components of the design solution.

All possible solutions are described by a maximum of eight components, each of which may appear in one of eight possible states. Solution components I have chosen for this application of Olden are as follows:

- Sleeping Component
- Dining Component
- Bathing and Toilet Component
- Free Leisure or Lounge Component
- Patient Circulation Component
- Exterior Configuration Component

A solution cannot be generated unless each component is represented. Only one state of each component may appear in any given solution. A few examples appear below:

Sleeping Component

Single patients bedroom/viewed from nursing station/moveable furniture

Single patients bedroom/viewed from nursing station/fixed furniture

Single patients bedroom/not viewed from nursing station/moveable furniture

Single patients bedroom/not viewed from nursing station/fixed furniture

Shared bedroom/viewed from nursing station/ moveable furniture

Shared bedroom/viewed from nursing station/ fixed furniture

Shared bedroom/not viewed from nursing station/moveable furniture

Shared bedroom/ not viewed from nursing station/fixed furniture

Bathing and Toilet Component

Bath and toilet adjacent to bedroom/shared between bedrooms/forms visual lock to corridor

Bath and toilet adjacent to bedroom/shared between bedrooms/forms no visual lock to corridor

Bath and toilet adjacent to bedroom/not shared/forms visual lock to corridor

Bath and toilet adjacent to bedroom/not shared/forms no visual lock to corridor

Bath and toilet in sector/near nursing station/private waiting areas

Bath and toilet in sector/near nursing station/no private waiting area

Bath and toilet in sector/ concealed from corridor/private waiting area

Bath and toilet in sector/concealed from corridor/no private waiting area

Possible states of other components can be seen in example solutions which will follow. Questions directed to the player of Olden are tailored to the selection of possible states of components which will ultimately be used to generate design solutions. The current version of Olden asks twenty-eight questions. Examples of some questions are given as follows:

Do you plan to have bathrooms adjoin each bedroom?

Does the bathroom form a visual lock between the public area of the corridor and the sleeping area?

Have you provided leisure spaces that are (1) dispersed throughout the institution or (2) have you provided one common lounge or one for each nursing unit?

Are sleeping areas (1) arranged along straight corridors or (2) are they clustered?

Can a patient view public activity from his communal lounge?

Would circulation through this space encourage furniture to be (1) alligned or (2) grouped?

Unseen by the player is a square matrix which contains all pair-wise incompatibilities between states of components. This matrix will be used by a morphological analysis algorithm to generate solutions, each of which will be a unique combination of states of the six components. For example, the bathroom component in the state,"Bath and toilet in bedroom/shared between bedrooms/forms visual lock to corridor", is incompatible with the sleeping component in the state,"Shared bedroom/viewed from nursing station/fixed furniture." These two states could not appear in the same solution, because a bathroom which forms a visual lock to the corridor would not allow the bedroom to be viewed from the nursing station. At this point in the explanation the player has had no effect on the incompatibility matrix. Entries in the matrix of "2" recording pairwise incompatibilities are employed to eliminate most ridiculous combinations of states. An entry of "1" records compatibility. (Figure 6)

In the process of answering questions put to him, the player himself begins to alter entries in the compatibility matrix. Each answer reduces the number of solutions which can be generated from the matrix. Each question may entirely eliminate the existence of a state of one component. If the player decides that he will have no single-occupant bedrooms, then an incompatibility will be recorded between all states of the bedroom components having single-patient bedrooms and all states of every other component. The density of incompatibilities is therefore greatly increased by the responses from the player.

		Compo 1								Compo 2								Compo 3								Compo 4								Compo 5							
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Compon 1	1									1	2	2	1	2	1	2	2	2	2	1	1	1	2	2	1	1	2	1	2	1	1	1	2	2	1	1	2	2	1	1	2
	2									1	2	2	2	1	2	1	2	1	1	2	1	2	1	1	2	1	2	1	1	1	1	1	1	2	2	2	1	1	2	1	2
	3									1	2	1	2	1	1	2	1	2	1	2	1	1	1	2	1	2	1	2	1	1	1	2	1	2	1	2	1	1	2	1	2
	4									1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2	1	2	1	1	1	2	1	2	1	2	1	2	1	1	1	1
	5									2	1	2	1	2	1	1	2	1	2	1	2	1	1	1	1	1	2	1	2	1	2	1	1	1	1	2	2	1	2	1	1
	6									1	2	1	2	1	2	2	2	2	2	2	1	1	1	1	1	2	2	1	2	1	2	1	1	2	1	2	1	2	1	2	1
	7									2	2	2	2	2	1	1	2	1	2	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	1	1	2	1	2	1	1
	8									1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1	2	1	2	1	1	1	2	1	2	1	1	1	1	1	2	1
Compon 2	1																	2	1	2	1	2	1	1	2	1	2	1	2	1	1	1	2	1	2	1	2	1	1	1	1
	2																	2	2	1	2	1	1	2	1	2	1	2	1	1	1	2	1	2	1	2	1	1	1	2	1
	3																	2	1	2	1	2	1	1	2	1	2	1	2	1	2	1	1	1	2	2	1	2	1	1	1
	4																	1	1	1	1	1	1	1	2	2	2	1	1	1	2	2	1	2	1	2	1	1	1	2	2
	5																	2	1	2	1	2	1	2	1	2	1	1	1	1	1	1	1	2	1	2	1	2	1	1	1
	6																	1	1	1	1	2	1	2	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	1	1
	7																	2	1	2	1	2	1	2	1	1	1	1	1	1	1	1	2	2	1	1	1	2	1	1	2
	8																	2	2	2	2	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2
Compon 3	1																									2	1	2	1	2	1	1	1	1	2	1	2	1	2	1	2
	2																									2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	1
	3																									1	1	1	1	2	2	1	1	1	1	1	1	2	2	1	1
	4																									1	2	1	2	1	2	1	2	1	2	1	2	2	2	2	2
	5																									2	2	1	1	2	1	1	1	1	2	1	2	1	1	1	2
	6																									2	1	1	1	1	2	1	2	1	1	2	2	2	2	1	2
	7																									2	1	1	1	2	1	2	1	2	1	1	2	1	2	1	1
	8																									1	1	1	1	1	2	1	2	1	1	1	2	1	2	1	2
Compon 4	1																																	2	2	2	2	2	2	1	2
	2																																	2	1	2	1	2	1	1	2
	3																																	2	1	2	1	2	1	1	2
	4																																	2	1	1	1	2	1	2	1
	5																																	2	2	2	1	2	1	1	2
	6																																	2	1	1	1	2	1	2	2
	7																																	1	1	1	1	1	2	2	1
	8																																	2	1	2	2	2	2	1	1

Figure 5.

Up to this point solutions have not been generated. To understand how an incompatibility matrix makes an exhaustive enumeration possible, we must appreciate the necessity for a reduction of combinatorial possibilities. A solution must contain all eight design components. One contradiction in two states eliminates the possibility of a solution. By using the computer we can enter an exhaustive search. The search is achieved in the following manner. The number of total combinations of states for solutions, disregarding incompatibilities, is calculated. A sequence of search starts by comparing state one of component one with state one of component two, state one of component three...then state two component one with state one of component two, state one of component three. If any incompatibility is discovered during one iteration through the nine components, then the search is indexed up to compare the next state of component one. An iteration may be called an attempt to find a combination of all design components having no incompatibilities. If in one iteration no incompatibility is found, an acceptable solution is recorded. Then the next state of component one is tested. This process will be continued until the number of iterations is equal to the total number of solutions possible. While the process of solution generation is quite simple, the number of iterations with their compatibility testing would be exhausting for all practical purposes. If design solutions are composed of eight components, each with eight or nine possible states, then one is faced with thousands of iterative comparisons.

As the player answers questions about the design of his geriatric home he is not, therefore directed toward the generation of one solution. While he restricts the number of states of components to those in agreement with his design intentions, the player may allow hundreds of alternative solutions to be proposed. Solutions would appear in the following form:

Sleeping component	Single-patient bedroom/ viewed from nursing station/moveable furniture
Dining component	One common dining room bounded by public space
Bathing and toilet component	Bath and toilet adjacent to bedroom/not shared/ forms visual lock to corridor
Free leisure or lounge component	Leisure spaces dispersed /no view of public activity/furniture grouped
Patient circulation component	Clustered circulation/ directed channels/overlap with staff circulation
External configuration component	Does not enclose exterior space/views public activity/shady orientation

Of course, many more alternative solutions could be generated. An algorithm developed by William H. Mitchell for catagorizing these solutions can be included in the solution generating routine. Clusters of solutions may be identified by either one disjunctive element or one conjunctive element. Sets of solutions related by a conjunctive element have a particular component appearing in the same state across all solutions. Sets of solutions related by a disjunctive element would have all components appearing in identical states with the exception of one inconsistent component.

Up to this point in the explanation of Olden the player's design decisions have not been evaluated. Although a set of possible solutions would have been generated, the player would have received no information regarding the success or failure of these solutions. How successful is each solution in providing a full continuum of community and privacy? We return now to the data which has been stored prior to the playing of the game. All states for all components were stored as a list of verbal statements, each of which would appear in the final alternative solutions having no pair-wise incompatibilities. Riding with each of these statements through the entire program is a numerical value. This value is obtained by weighting the perspective parts of the statement along a scale from one to ten for their provision of maximization of choice in community and privacy. Weighting of each descriptive portion of a state is shown as follows:

Component	State
Bathing and Toilet	Bath and toilet adjacent (10) to bedroom/not shared/ (10) forms visual lock to (10) corridor (state score 30)
Bathing and Toilet	Bath and toilet adjacent (10) to bedroom/shared/does (5) not form visual lock to (2) corridor (state score 17)

Scores for each portion of the state are given through qualitative evaluation. This evaluation of elemental parts should give greater accuracy in performance than an evaluation of each state as a whole. Each solution is found through the sum of the scores of the individual parts. From the values assigned for all states of all components, I have selected the optimal solution which contains the highest valued states for all components. The score for this solution can then be used as a yardstick against which all other generated solutions can be measured. Any solution's success in offering a full spectrum of community and privacy is measured as a per cent of the highest obtainable score held by the optimal solution. The score for each solution is simply calculated by dividing the sum of the scores for the individual states by the score of the optimal solution. This percent of optimization, though not rigorously accurate does become a reference for ranking solutions.

At this moment, Olden cannot offer a specific spatial organization to the designer. Olden does seem to work best as a game for causing an awareness in designer or builder of geriatric institutions of a dimension of design beyond aesthetic, functional or economic concerns. Most important is that spatial arrangements are graded from the patient's point of view rather than from efficiency of staff activities. Persons other than myself and a few architectural students have not used Olden to measure the effects of their design intentions. Olden has led these students towards a greater awareness of the geriatric environmental structure. The game is too limited, however. Too few questions are asked in order to formulate a comprehensive manipulation of the great number of spaces and circulation systems which make up a geriatric institution. At this moment, the morphological analysis cannot handle more than nine components, each with nine states. Even with this limited number of components and states, approximately 6500 binary decisions must be made before the incompatibility matrix can be stored. Olden is most successful as an academic search for a method of generating solutions which can possibly be graded for the designer. The structure of Olden could be adapted for producing and measuring solutions on the many other dimensions of evaluation which are so frequently ignored. When a designer finds a solution which works well along every dimension, with the exception of one which has few economic implications, then he generally has the tendency to ignore that dimension. Olden will not allow this kind of convenient neglect. If the purpose of Olden is to become an advocate for the elderly then I believe that the game succeeds, for it forces recognition by one party of the subtle needs of another group of people. The form of Olden does not limit its application to architectural problem solving. It does address itself to that characteristic quality of architectural design in which the architect limits choice through design decisions. The structure of Olden is most helpful in visually pointing out to the architect the decrease in the volume of solutions or options which comes with each move toward a definition of specific spaces.

The greatest deficiency of Olden lies in the mathematical procedure used for evaluating solutions. Each of us knows that an aggregation of environmental elements can create a situation in which the whole is not equal to the sum of the parts. Components in the following states in one solution could produce this situation:

Bedroom Component	Shared patients bedroom/ viewed from nurses station/fixed furniture
Bathing and Toilet Component	Bath and toilet in sector /near nurses station/ no private space for waiting

Since both of these states describe an extreme absence of privacy, each state might negatively reinforce one another. Scores for each statement should then be lowered beyond the initial value for each state. Here we come to a nearly insurmountable problem. A rearrangement of initial values might be required for each combination of states to find an accurate score for each solution. Of course one might also find that positive reinforcement could raise scores for individual states beyond their initial values. Ranking solutions only for their success along the community/privacy dimension is done at the exclusion of a variety of other dimensions also affecting the psychological well-being of the geriatric resident. I would not push for multidimensional measurement in order to include the dimension of economic efficiency. My primary objective is that the designer realize how spatial organization can reinforce positive interaction among residents of a home.

Until a more suitable mathematics for grading the success of solutions is found, Olden may not prove useful in practical application. Subjective judgement of the worth of states in each solution could leave the player of the game baffled about the basis for scoring. Indeed, a very detailed explanation of the dilemma of the elderly and their tendency toward disengagement in institutional living must be provided after the game has been played. The player must connect the scoring to the philosophy behind such scoring.

Beyond satisfying certain physiological requirements for users, architects do not usually produce solutions having quantifiable results. Still, architects should not delay using the computer as a partner in seeking qualitative excellence in design. In Olden the architect also begins to learn the range of solutions allowed by one philosophy. The computer has invaded that uneasy realm of grading solutions on their adherence to a particular design philosophy. Of course we need to measure such adherance along more than one dimension such as the community/privacy continuum. Multiple solution generation which indicates a negative bias on the part of the designer will force the designer to recognize psychological and social tendencies.

Notes

(1) "Reflections on Group Living of the Aged" (Anonymous), Geriatrics, IX (August 1960).

(2) Mathiasen, Geneva, "Trends in Housing for Older People", Architectural Record, CXXXII (December 1962).

(3) Townsen, Peter, The Family Life of Old People, (London,1963).

(4) Goffman, Irving, Asylums, (New York,1961).

(5) Klein, Wilma, Promoting Mental Health of Old People Through Group Methods, (New York, 1966).

(6) Ibid.

DISCRIMINATION BY DESIGN: MOBILITY BARRIERS

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The Nature of the Problem

People with mobility limitations are not permitted to use many public accomodations because it is physically impossible for them to gain access to the facility. Others they may use, but only with inconvenience, imposition on others and potential danger. The population under discussion includes people with permanent or temporary disabilities stemming from illnesses, injuries or birth accidents; the aging and aged; people with energy limitations due to chronic illnesses; pregnant women; women (or men) with baby strollers, shopping carts, little children to ride herd on, arms laden with packages; small people (children and dwarfs); and the families and other companions of all these. Such people comprise a minimum of 20% of the population; that's 40,000,000 people, a large minority.

The reason for the problem is thoughtlessness in design and careless compliance with design specifications. There is no malice aforethought. "It just never occured to me."

There are three types of issues involved. The first is humanistic. It is not kind to deny a segment of humanity the use and enjoyment of what the rest can use and enjoy when the situation is correctable. The prerequisite to correction is simply concern.

The second is economic. It is not economically sound to spend millions of tax and private dollars to save and rehabilitate the aged and disabled if they still can't function in the world because of needless, man-made barriers. Owners of facilities lose revenue which would come from customers turned away by the barriers and the government loses revenue when skilled people aren't working because the places of employment or transportation to employment are inaccessible.

The third is legal and has both statutory and constitutional aspects.

a. Statutory: At the federal level, public law 90-480, passed by the 90th congress in 1968, was enacted to insure that buildings financed in whole or in part by federal funds or to be leased by the United States are so designed and constructed as to be accessible to and usable by the physically handicapped. "Building" here includes any facility (other than private residences or certain military facilities) intended for use that might require public access or result in the employment or residence therein of physically handicapped individuals. Also at the federal level, the 1970 Biaggi amendment added to the Urban Mass Transportation Act of 1964, a section stating "It is hereby declared to be the national policy that elderly and handicapped persons have the same right as other persons to utilize mass transportation facilities and services". This amendment also authorizes the Secretary of Transportation to make grants or loans for the specific purposes of assisting States in providing mass transportation services which are planned, designed and carried out so as to meet the special needs of elderly and handicapped persons.

The impact of federal legislation is limited, in that it can only affect construction which involves federal funds, or, in the case of certain desired transportation-related legislation, where interstate commerce is involved. Perhaps the major value of federal legislation is to serve as an impetus to States to pass similar laws which will have more far-reaching effects. California shows good examples of this. Section 54 of the California Civil Code states, "Blind persons, visually handicapped persons and other physically disabled persons shall have the same right as the able-bodied to the full and free use of the streets, highways, sidewalks, walkways, public buildings, public facilities, and other public places. Section 54.1 specifies that they shall be entitled to full and equal access, as other members of the general public, to accomodations, advantages, facilities and privileges of all common carriers, airplanes, motor vehicles, railroad trains, motor-buses, streetcars, boats or any public conveyances or modes of transportation, hotels, lodging places, places of public accomodation, amusement or resort, and other places to which the general public is invited and all housing accomodations offered for rent, lease or compensation in this state.

The question immediately arises, "what does it mean to have a *right* to do something if it is physically impossible to actually do it?" Say I use a wheelchair. This law gives me the right to attend the church of my choice. The front door has 17 steps and the back door has six. I cannot exercise my right. If I cannot exercise it, do I really have it? The following pieces of California legislation come a little closer to offering avenues for implementation.

Chapter 7 (commencing with Section 4450) of Division 5 of Title 1 of the California Government Code states, "it is the purpose of this chapter to insure that buildings and facilities, constructed in the State by the use of state, county or municipal funds, or the funds of any political sub-division of the state, adhere to the American Standards Association Specifications A 117.1-1961 for making buildings and facilities accessible to and usable by the physically handicapped. Section 4451 states "... this chapter shall apply to all buildings and facilities intended for use by the public, which have any reasonable availability to, or usage by, physically handicapped persons, including the University of California, the California State Colleges and the various junior college districts..." Section 4452 states, "Any unauthorized deviation from these specifications shall be rectified by full compliance within 90 days after discovery of the deviation." Section 4453 states, "The responsibility for enforcement of this chapter shall be as follows: (a) Where state funds are utilized, by the Director of the Department of General Services. (b) Where funds of counties, municipalities, or other political sub-divisions are utilized, by the governing body thereof."

Thus, this bill specifies some means by which a theoretical right can become a reality. It is also potentially enforceable and attention is directed to ensuring that it *is* enforced.

That law was passed in 1968. The following year, a similar law was passed, which added Part 5.5 (commencing with Section 19955) to Division 13 of the California Health and Safety Code. It states, "The purpose of this part is to insure that public accomodations constructed in this state with *private* funds adhere to the provisions of Chapter 7 (commencing with Section 4450) of Division 5 of Title 1 of the Government Code. For the purposes of this part, "public accomodations" means a building, structure, or improved area which is used primarily by the general public as a place of gathering or amusement, including theaters, restaurants, hotels and stadiums."

Thus, in California, privately-funded, as well as publicly-funded construction of "public accomodations" come under the law and must meet at least the minimum standards set forth in the American Standards Specifications.

A final piece of legislation to be mentioned is Assembly Bill 710 which was signed by the Governor of California in September of 1971. This includes equipment of rapid transit districts intended for use by the public at large within the definition of public facilities to be accessible to the handicapped.

b. *Constitutional*: Not yet put to the test in court but of growing concern are the possibilities that the existence of non-accessible public facilities may constitute discrimination against a minority group and deprivation of that groups' constitutional rights.

In addition, the Code Change Committee approved the following additions to the Uniform Building Code when they met in Kansas City on June 10 and 11 of 1971.

Section 1711 (A), to be added to the Code, reads, "Except in group E, H, I and J occupancies, where toilet facilities are provided, at least one water closet compartment for each sex shall be at least three feet wide by five feet in depth, having a door (if used) that is at least 32 inches wide and swings out of the compartment. The compartment shall be provided with handrails on each side. Such facilities shall be suitably identified."

Section 1711 (C) reads, "Except in Group E, H, I and J occupancies, doors to toilet rooms shall have a minimum net opening of 32 inches in width."

Section 3301 reads, "(1) Building Access. In Group A, B, C, D and F occupancies and hotels, at least one primary entrance shall be accessible to and usable by individuals in wheelchairs. Where elevators are provided, such entrance shall provide access to a level served by an elevator."

An abbreviated definition of the occupancy groups mentioned is:

A = places of assembly of 1,000 or more persons
B = less than 1,000
C = schools
D = hospitals, nurseries, nursing homes
E = storage, factories/combustibles and repair garages
F = service stations, stores, office buildings, restaurants, parking garages
H = hotels and apartment houses
I = dwellings
J = garages

Avenues to Solution of the Problem

Obviously, the legislation and building regulation changes just summarized by way of explicating the nature of the problem also constitute critical steps toward solution of the problem. But they haven't solved the problem and in the opinion of some, they have generated a new one. Specifically, now that we've got them (the disabled) in, how do we get them out (in case of emergency)? Let us look at each in turn.

Legislation hasn't solved the problem for the simple reason that the law is not consistently met. When it is not met, rectification is not consistently enforced. There are several reasons.

First, many designers, planners, builders, facility owners and managers, building officials, community decision-makers and enforcers, plan checkers, et cetera, are unaware that the laws or regulations exist. Ignorance of the law may be no excuse, but it is a very effective deterrent to action. Massive mailing campaigns wherein copies of the relevant laws and an explanatory cover letter have been sent to building officials throughout the state, and regional workshops funded by the Social and Rehabilitation Service of HEW for members of the American Institute of Architects comprise examples of efforts made to correct this source of failure.

Even when the designer and other involved decision-makers are aware of the legislation, the law may not be met because it is not understood. This may be because the law is not as understandable as it should be (and we know this is true; for example, the interpretation of what constitutes a "public accomodation" may vary widely because it has not been explicitly defined in the law). It may also be because the interpreter seeking to limit the extent to which pre-existing design considerations must be altered in order to meet minimal standards of compliance with the law, or seeking to minimize costs, chooses to understand the law as either non-applicable or having very limited applicability. Sometimes this may be observed by the plan checker, but the Los Angeles Convention Center attests to the fact that this may not be relied upon. When an alert citizen noted that the only way for a wheelchair user to get into the Center was through the parking facility - which might be fine if the person parked there, but involved a difficult and hazardous journey to reach the access if he/she were unwittingly dropped off, say, at the front door where most people expect to enter - approximately $65,000 worth of revamping this already expensive facility to bring it into line with the spirit and intent of the law were required.

Barrier free design is expensive when it is done this way - after the fact. There is controversy over whether, in the long run, it would involve greater costs if the concepts were integrated into the original plans. Some aspects we know cost more, like providing elevators where only stairs might have been used. Some would yield money savings, like the avoidance of split level designs. In some cases costs may not be affected - like placing elevator controls a foot lower. In still other cases, cost factors may tend to balance out; for example, ramps require more space but cost less to construct than stairs. It would be possible to design study strategies which would resolve this controversy. It would also be exceedingly costly of time and money and unless alternate outcomes are going to be associated with different sets of decisions, I am not sure there's much point in doing it. Obviously, if barrier free design proved to save money, it would be just that much easier for its advocates to "sell". But lets say it proves beyond a doubt to be more costly. What then? Are we to conclude that barrier free design is therefore infeasible?

Do we conclude that safety features on power machinery are an infeasible frippery because the cost of the tool increases and only about 10% of the people who use them are going to cut off their fingers anyway? It seems to me that once having noticed the problem, we are stuck with the responsibility for solving it even if it means facing the unpleasant reality that building is going to cost more than it used to.

The foregoing has illustrated three avenues toward problem solution - education, research and social action. The mailing campaigns and workshops illustrate the educational aspect - "first you have to get their attention". Cost studies are an example of one type of research that has been called for. The legislation itself and the alert citizens who bring attention to non-compliance are examples of social action. I believe essentially all of the efforts to solve the accessibility-usability problem may be subsumed under one of these rubrics.

This is also true for the new problem allegedly created by legislation which neglected emergency evacuation consideration.

This brings us to the question of the hour, What remains to be done and of that, what can we do?

First of all, schools of architecture and urban planning can make sure that the concepts of barrier free design are included in the curricula so that no student could graduate without being an expert on the subject. A few generations of students from now, the label "barrier free design" should tend to disappear from use, having become so thoroughly a part of general design practice and expectation that it is no longer thought of as a special consideration. In the past when I have made this remark, a few people have hesitantly suggested that designing the entire world for a few unfortunates might be unwarranted. Recalling the description of the population involved, it is not just a few unfortunates. If we're lucky, we'll all grow old enough to appreciate the revolution. And we may as well face it, with continuing wars and psychopathic use of the automobile, coupled with an advancing science of medicine which is delivering the victims back to the mainstream of life rather than burying them, the per capita "unfortunates" is a figure that grows ever larger.

An interesting sidelight is that consistently, when a ramp is added to an older building which also has stairs, able-bodied users abandon the stairs and join the disabled on the ramp. It seems that what is necessary for the mobility-limited is also preferred by the able-bodied - no one likes to work harder than necessary. There are exceptions, of course. A six foot man doesn't relish bending over to drink from a water fountain situated for the convenience of little children and wheelchair users. But dual level water fountains have been around for a long time, and there are no sanctions against separate but equal facilities in this area.

An exceedingly important aspect of the needed education, is self education. After you've committed all the laws to memory and read every available book, treatise and report on the subject, try to plan, build or evaluate someone elses plans for a building. Will you overlook anything? Chances are you will. There's just no way to really become aware of the "little things" that can sabotage barrier free design without experiencing the effects of limited mobility for yourself. You don't have to break a leg. Just borrow a wheelchair for a week - or even a day - and see what happens as you go about your normal business at home, at work, at school, shopping, et cetera. The "things that would never have occurred to you" will become perfectly clear. Einsteinian "thought experiments" may help, especially after the wheelchair tryout, which should free the imagination somewhat. For example, you are using both arms to wheel your chair. You have your briefcase and two books on your lap. You wheel up to the ramp which has been provided. But the cement finisher, who never heard of mobility barriers and has perfectly good ways of doing things that he's been using for years, left a one and a quarter inch rise at the foot of the ramp. Contact. Now pick up your books - if you can reach them. Get your briefcase off your foot. By the way, how is your foot? This simple thought experiment reveals that it is not just university trained specialists who must be educated, but apprenticeship training in the building trades must also include material on mobility barriers. From here we can go through the entire chain of specialists and workers who may make a decision or follow an instruction at any point in the building process - from inception of idea to completion of landscaping, isolate the channels of training input to those individuals and know that here is another place where "curricula" need to be injected with these concepts.

When "research" is listed among solution alternatives, I always ask myself this question. Do we really need to gather more information before we take action or do we just need to establish our priorities and start doing something? I think research often gets done because we imagine ourselves incompetent to act without knowing more about something. The problem is, it can become a never-ending process of postponing action and looking for that magical last bit of data that's going to make everything fall into place. I've heard calls for research into the "nature and extent of the need", but if you get one octogenarian, one wheelchair user, one blind person, one deaf person, a pregnant lady and a little kid in a room together, they can tell you everything you need to know. They can outline five generations worth of work to do on the world and when that's done will be soon enough to start searching for additional needs. For those who are made uneasy by the lack of system suggested by these urgings to "start somewhere", the people in that room can provide enough information to keep a systems analyst waist deep in flow charts for a year. We don't need much "need research" anymore, and in some areas we don't need much "solution research" either. Regarding accessibility of buildings, for example, the solution course is fairly well charted. Areas which do need research are: (1) solutions for emergency evacuation, especially from multi-story buildings, and (2) ways of making public transportation systems usable by all including wheelchair users. Even here there is less research left to do than might be imagined. Professor Nugent at the University of Illinois directed a project which yielded a very safe, serviceable and economical hydraulic lift which can be installed at the front door of most any overland bus. General Motors has developed a prototype bus which a wheelchair user can enter and leave as well as he can manage a high curb (which is not easy, but at least it is possible). A GM representative informed me that the company recently canvassed rapid transit districts all over the country. He indicated that the concensus was no interest on the part of the transit districts - they were not willing to accept the reduced seating capacity (by seven seats) which the design entailed. In California, now that AB710 has passed, perhaps seating capacity and accessibility will cease to be viewed as trade-offs. Now that the shortcoming has been noticed, it should follow that new buses must either be larger or will have to seat fewer persons. Interestingly enough, both the Nugent and GM designs offer increased standing room during peak hours and more than adequate seating during non-peak hours for most communities.

Public transportation brings us to a third area which requires a great deal of study to ensure that no thoughtless slip-ups bar a segment of the public from not only single facilities, but vast complexes of facilities. I am referring to urban planning related to business centers involving the gamut of people-moving systems (from sidewalks to, perhaps, air cushion rapid transit systems) and facilities concerned with virtually all of the essential supplies and services recuired or desired by the general public. More and more, these days, we read about communities planning to "rope off" an old downtown area; provide massive parking facilities at the outskirts, allow no automobile traffic within it and provide shuttle service instead. We'd better make sure that all the people who have the desire and the right to use the complex are able to board the tram. There are some such plans afoot for the downtown Los Angeles area. The RTD's minibuses could have gotton us off to a good start. The Minibus Corporation has the technology for making accessible buses - they've done it for the Los Angeles County Department of Hospitals and for an eastern community that requested wheelchair accessibility for a local shuttlebus. But the company's specifications not only neglected lifts or even ramps, they called for a door that is one inch narrower than a standard adult wheelchair. They are concerned that it takes 12 seconds to board a wheelchair as opposed to only 4, I believe, for customary boarding. Admittedly, time is money, but I wonder how many wheelchairs, how many seconds, how many cents, would be involved each day?

A colleague of mine in the Urban Planning Section of the Los Angeles City Planning Department described a multi-level shopping complex that is in-plan. On analysis, it turns out that every other level of the complex would be accessible to people in wheelchairs. Unfortunately, the alternate levels would involve a few steps. When I pointed this out as a problem this was received as indeed an unfortunate reality. This kind of planning must be interrupted, scrapped if necessary, and adequate planning initiated. This may require enormous amounts of research and development, or it may not. Experts in the fields of architecture, urban planning and transportation can answer this better than I.

In the social action arena two of the most critical needs right now are to add to the existing legislation sections requiring additional provision for safe evacuation of mobility-limited individuals from multi-story structures in emergency situations, and improving the extent to which we may all rely upon the officials who review plans for construction or area development to note and take appropriate, timely action when failures to meet the law arrive at their desk. Locally, plan checkers in the Los Angeles County Department of Engineering check the plans of every building that is to be constructed within the boundaries of the County, whether public or private funds are to be used. The department is aware of the legislation, of course, and they are conscientiously trying to meet their responsibilities. One of their plan checkers is a wheelchair user and undoubtedly is able to add materially to the insight of all staff in their reviewing function. But even here, many failures go unnoticed and many instances of "minimal compliance" which are not adequate solutions are approved but should not be. The problem for designers and builders is, if they can't count on the plan checkers to bring oversights or inadequacies to their attention while the facility is still in the planning stage, they may be faced with legal action and costly modifications after the building is completed. Written requests for special attention to mobility barrier aspects attached to all plans submitted for review should make it clear to these officials that we are counting on them for expert help during the transitional years as all concerned are establishing firm understanding of the basics as well as the subtler nuances of this new set of expectations for functional design for all.

ENVIRONMENTAL DESIGN: RESEARCH AND PRACTICE TWO

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DESIGN: THE GENERATION AND EXPLORATION OF SOLUTIONS

16: COMPREHENSIVE DESIGN STRATEGIES

THE SITE PLANNING PROCESS: ACTIVITY ALLOCATION AT THE URBAN FRINGE

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Introduction

The management of large units of land and water has evolved from the thoughtful but unconstructed recommendations of naturalists to the duller but more analytical work of planning agencies involved with such resources as forest, agriculture, water, health and recreation. Historically, the idea that landscape is itself a resource to be managed like the others, has grown more slowly. As public awareness and professional attention have increased, analysis of landscape has focused on the basic elements of landform, water, soils, vegetation, and wildlife and their subcomponents, or descriptors, that serve as keys to the past history, present condition and future potential of the landscape. The disciplines that have emerged to deal with the changing relations of these elements to other facets of urbanism are concerned with the comprehensive management of space and resources for human habitation and sustenance.

Traditionally, the effectiveness of these disciplines rested on easy assumptions of social continuity that allow linear projection from past experience to future states of physical reality. Presently, decisions affecting planning are impeded by diffuse value systems and especially by the short time between the inception of an idea and the social consequences of its implementation. It is possible, and increasingly necessary, to develop techniques that allow predictive planning decisions to be made within the same short time that witnesses physical change.

Like beaches, coastal marshes, and foothills, the urban fringe is a transition zone, a set of links between one concentrated activity (the urban core) and several dispersed areas of activity (sources of water, food and recreation land). The importance of these transition zones lies in their potential diversity, which implies their ability similtaneously to mediate the needs of a number of boundry conditions. The natural resource base of a city is not a point or a zone, but is widely dispersed, and the demands made upon this base by the processes inherent in urban growth are distinctly non-uniform; the spatial and socio-economic heterogeneity of supplies and demands provides the problems and the challenges, or urban planning.

This paper is a report on a series of studies in the Halifax Metropolitan Region supported by a research grant from the Canada Council. (1) Inevitably, it concentrates on the methodological framework in which alternative options for urban growth are generated and organized, and leaves decision-making processes for later consideration.

The Study Area

In order to explore the implications of alternature forms of growth at the urban fringe, a comparative case-study format was developed for a system of watersheds at the fringe of Halifax, Nova Scotia.

Appropriate boundaries for a study area might be determined by political, social, economic or physical constraints. The natural scientist tends to define a study area in terms of natural systems; the politician thinks of electoral districts; the economist deals with raw materials, manufacturing plants and labour sources. The regional planner is forced to work with all these parameters, usually constrained by pre-existing patterns of property ownership. In the prototype area selected for this study, most of these problems are simplified into a close approach to a 'free body diagram' by the existence of the "Halifax Watersheds" which are protected, public property, managed by the 'Public Service Commission' as a water supply source for Halifax. The land, scheduled for potential development in the future includes the Long Lake and Chain Lakes watershed, whose total surficial land area is 4179 acres, approximately equal in size to the Halifax Peninsula.

Site Planning Format

The site planning process, as conceived, is divided into three phases. The first, the allocation of activity, is fundamentally descriptive, though of process as well as structure, and organizes the site and its potential activities into a development framework that can be tested, in the second phase, against the needs of users. A major advantage of this approach is that this preliminary phase of testing can be carried out hypothetically, by a variety of appropriate simulations, before a single decision is made or contract drawn. In the third phase comprehensive design schemata are formulated, which, having acquired explicitness from the testing process in phase II, can in principle be tested in the real world as socially desirable or undesirable, rather than merely possible or feasible in an engineering or economic sense.

If a society is to make rational decisions about environment and resources, no one of these phases is more important than another. What is of critical importance is that they be considered sequencially; phase III is too late for rational decision-making if phase I and II have already been passed over, either unwittingly or by default.

Though a strong attempt is made to keep phase I objectively desriptive, it is not possible to describe an area that is to be used without some reference and projection of the needs of the users. We must assume, for instance, that the predominant number of potential users are North American, not African, and that they will live, work and communicate as other North Americans. Beyond such elements any constraints or descriptions or more abstract features of human personality needs and aspirations, have undoubtedly slipped into the descriptive program of phase I. In fact, the sequential format outlined (fig.1) specifically allows for repetition with variance (re-cycling) and permits both hindsight and forforesight at the same time at each of the various steps in the proposed planning process. Some kinds of user needs, and the gaming procedures developed to incorporate them proleptically into activity allocation, are indicated in appropriate places in the description that follows.

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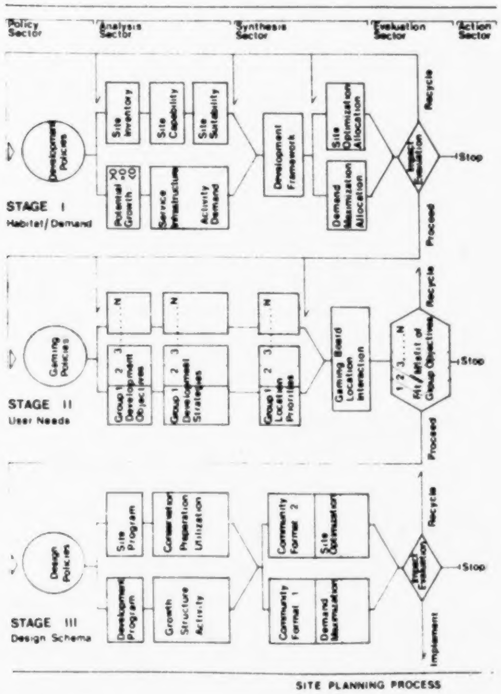
Policy Sector
Analysis Sector
Synthesis Sector
Evaluation Sector
Action Sector
Development Policies
STAGE I
Habitat/Demand
Site Inventory
Site Capability
Site Suitability
Potential Growth
Service Infrastructure
Activity Demand
Development Framework
Site Optimization Allocation
Demand Maximization Allocation
Impact Evaluation
Recycle
Stop
Proceed
Gaming Policies
STAGE II
User Needs
N
Group 1 2 3 Development Objectives
Group 1 2 3 Development Strategies
Group 1 2 3 Location Priorities
Gaming Board Location Interaction
1 2 3 ... N Fit/Misfit of Group Objectives
Recycle
Stop
Proceed
Design Policies
STAGE III
Design Schema
Site Program
Conservation Preparation Utilization
Development Program
Growth Structure Activity
Community Format 2
Site Optimization
Community Format 1
Demand Maximization
Impact Evaluation
Recycle
Stop
Implement
SITE PLANNING PROCESS

Figure 1.

In the process as applied to the Long Lake and Chain Lakes watershed land near Halifax, phase II is actively under way and consideration is being given, by public authorities, but not yet by the general public, to early entrance on phase III. Decisions will be made soon even though all options are not entirely clear, including the option not to develop the watershed lands. In this report stress is placed on the procedures developed in phase I because more attention than usual has been paid to processes, and the descriptive procedures are in part novel. These are abstracted here in the belief that they have enough generality to be useful to other planners and designers in other communities.

Activity Allocation

As a basis for study, the proposed activity allocation process describes the component elements utilized in the site planning process that are required to activate, formulate, and evaluate the allocation and structure of activities to a study area. These components are the generation of policy, the analysis of the internal resources of a study area, the synthesis of these resources with respect to external metropolitan demands and finally, an evaluation of the impact that development might exert on the study area through time.

1. Policy

Policy stems from an expressed need for change in the existing conditions; a result of historic precedent, present demand, or projected needs. Thus policy must be formulated to stimulate alternative and flexible options that can accommodate the complex inter-actions of multiple-factor investigations. Policy statements directed to urban growth, however, have typically been associated with the investigation of isolated factors such as transportation, water supply, sewage disposal, conservation etc. Resultant proposals are seldom concerned with the associated impacts generated by the original investigation.

The watershed study, therefore, formulates policy assumptions that are intended to guide the investigation of the resources of the study area as they relate to the demands generated by the region. Specifically, the urban growth potential is explored with reference to (1) the natural resources (water, soil, vegetation), (2) the economic resources (utilities, roads, land-use) (3) the human resources (population, age, density) and (4) the perceptual resources (views, vistas, landmarks). (2)

2. Analysis

The proposed analysis model, developed to study the regional landscape and its relationship to urban growth, is based on a series of site capability and site suitability studies. (3) These studies of the resource potential of the site are then combined with the regional demand for development to produce a range of site feasibility studies that might serve as a basis for alternate development proposals.

In the context of the study process proposed, capability is defined as the natural capacity of a unit of water or land to support, at the highest level possible, any given use. The concept of suitability represents the relative amount of energy necessary to realize a proposed development activity, while feasibility represents the short term and long range benefit/cost ratio of utilizing a landscape unit for a proposed activity. The criteria for the study of site capabilities and site suitabilities are primarily resource based studies with the economic potential of the region and the social and perceptual needs of the residents of that region.

The information bank records relevant site data based on measures of the potential change in existing natural, economic, social and perceptual characteristics of the region in question. The design of the data bank requires that the data refer to locational situations with a need for flexibility of size, scale and quantity of maps. A two dimensional solution to three dimensional data, utilized for this study, is a grid system based on XY coordinates with a basic unit of 1/100 of a kilometer, or 1 hectare.

Given the desired size of "grid" appropriate to the study, the development of a data bank is Frequently limited by access to or availability of information that relates to the area to be studied. Data that can be obtained is typically classified at a variety of scales and a broad range of detail. To supplement these sources of data, air photo interpretation has been used as a rapid means of observing and recording the natural features of the study area. This technique provides current information, at a scale consistent with the proposed data bank design. All data is therefore made location specific and filed with references to the UTM grid coordinate system within the study area.

Within the four data clusters acquired for the study area the first (D_1) describes the natural components of the landscape in their present condition. Emphasis is placed on the description of those aspects that can most readily be associated with and influenced by companion systems within the total bank. Thus soils are not classified by name, but by particle size, mineral composition and depth -- physical features that bear directly on their development potential. Similarly, for vegetation associations, both quality and density are evaluated; quality relates to 1) the support of wildlife, 2) recreation potential, and 3) the perception of the landscape. This is one of those points at which user needs are anticipated in the description of the data. Certain climatic characteristics are ubiquitous and others unique to the study area. The former include percipitation, wind, airshed data, and solar statistics; the latter refers specifically to the neighbouring ocean, the source of salt spray and of warm moist winds.

The selected study area is unusual in that it is a large area protected, up to now, from normal land-use activities typical of the urban fringe. The objective data recorded in the economic development cluster (D_2) and the economic decisions that result can interact successfully in such an area if they eliminate superfluous or infeasible activity allocation, or serve as a means of monitoring changes generated by alternate development proposals. The data within the social/behavioral cluster (D_3) is limited to demographic information, while the final cluster (D_4) records those measures of the present perceptual pattern that characterize the study area.

The network of site capability and site suitability (Fig. 2) is derived from the basic data bank developed for the watershed study area. The capability of the study area to support land-use development is a function of the extent to which the site must be modified to support proposed development and represents the first derivative of the data. The basic premis of site suitability studies, is that the energy/cost ratio tends to decrease as major site modifications increase. There are obviously a range of exceptions to this concept, such as the transformation of poorly drained land to a pond in a proposed residential district, but these possibilities are more profitably explored in phase III, Design Development.

The basic elements of the landscape used as data for regional landscape studies are common to most analysis techniques, although the manner in which they are combined varies quite considerably. Depending on varying project needs, the characteristics of the region, and the approach adopted by the planning and design team. Observations are usually recorded in some manner that arranges the information from most desirable to least desirable, and all data is assumed to relate to the regional study or substudies in a linear manner.

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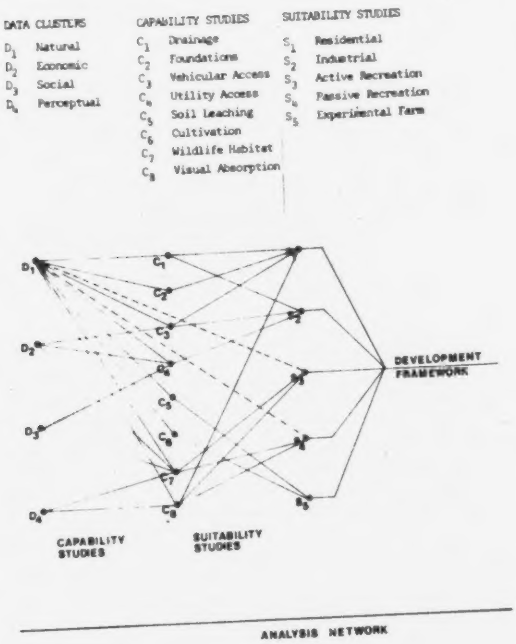
DATA CLUSTERS
D_1 Natural
D_2 Economic
D_3 Social
D_4 Perceptual
CAPABILITY STUDIES
C_1 Drainage
C_2 Foundations
C_3 Vehicular Access
C_4 Utility Access
C_5 Soil Leaching
C_6 Cultivation
C_7 Wildlife Habitat
C_8 Visual Absorption
SUITABILITY STUDIES
S_1 Residential
S_2 Industrial
S_3 Active Recreation
S_4 Passive Recreation
S_5 Experimental Farm
D_1
D_2
D_3
D_4
C_1
C_2
C_3
C_4
C_5
C_6
C_7
C_8
S_1
S_2
S_3
S_4
S_5
DEVELOPMENT FRAMEWORK
CAPABILITY STUDIES
SUITABILITY STUDIES
ANALYSIS NETWORK

Figure 2.

The specific relationship of each independent variable to a dependent study topic , however, is seldom direct. Four basic types of functional relations are proposed to more fully describe these interactions while balancing a reasonable level of analytic accuracy and the intended operational utility of the results. These relationships are linear, quadratic, exponential and step functions. Examples of direct relationships occur when the increase or decrease of a variable (soil depth) affects a study topic (internal site drainage) in a linear manner. Exponential curves describe the effect of some variables (increased time/distance) on the relative attractiveness of activity locations (shopping centers). Quadratic curves serve to moderate the influence of a variable at either extreme of an interaction graph. Finally, step functions are used to describe discontinuous relationships within a variable, such as major or minor surficial drainage courses.

In addition to these relationships, weights can be assigned to each variable prior to their functional integration as either a site capability or site suitability study, in order to express their relative importance to the specific study at hand. The fusion of variables, their weights, and the equations which describe their interaction are combined to produce a final map output for each capability and suitability study topic examined.

In the analysis procedure proposed, data variables are recorded on a numerical scale of ten equal intervals, and the explicit studies of site capabilities and site suitabilities are then evaluated on a similar scale of ten equal intervals. Those data sets that can be described in smaller increments are usually scaled as ratios internally and thus can eventually be aggregated to ten levels for analysis purposes. Four scales can be used in the classification of data. Nominal scaling is used to describe qualitative types of data without reference to relative value. Ordinal scaling assigns relative order to the data but not magnitutde, while interval scales are used when both relative order and magnitude are significant. Finally, ratio scaling establishes a fixed base value that allows quantitative measures, expressed as ratios, to be analysed in terms of mathematical functions. Consequently, a serious attempt is made to bring all data within the formats of of ratio scaling.

Theoretically, if each of six variables were plotted for the ten internal data levels available in the data bank, one million values might result. Operationally, the need for a full range of 10^6 values is seldom warranted in the analysis of a regional landscape, and consequently the number of value groupings must be selectively limited. This process of data aggregation can be achieved through simple computer programming or by a graphic, hand manipulated process that includes the manner in which the data is scaled, the importance or weight assigned to each data set, the functional relationships of a data set to the landscape study in question, and finally the minimum number of levels in which the data may be sub-divided.

The proposed graphic format assumes that a relative scale can be established for all variables to be considered that consists of an origin and terminus. The absolute length of the scale is divided into ten units, and by definition accommodates the highest value of the largest variable to be considered.

Weighting of the variables is achieved graphically, by shifting the terminal point for each of the variables to be considered. Weights are assigned on the basis of ratios, the highest of which is 1:1.0 utilizing the full length of the absolute scale.

Functional relations between variables are plotted on the absolute scale, and length of that scale established by the weights assigned to each variable, utilizing graphic approximations of linear, quadratic, exponential and step. The number of levels recorded for each variable must exceed the minimum number necessary to describe graphically the functions referred to above.

In the example illustrated (C_1), five data categories are combined to develop a profile of the internal site drainage capability of a study area. Weights are assigned to each of data groups selected based on their relative influence in determining internal drainage. The appropriate functional relationships are chosen as are the number of relevant levels of data within each group. The required information is grouped and the process of plotting the data is explained in the steps that follow. The resultant graphic diagram is analogous to a contour map that establishes equal groups of information (elevation differentials) within a bi-polar frame of reference (high to low).

C1 DATA	LEVELS	WEIGHTS	FUNCTION
Topo Slope	4 levels	1:0.83 WT.	QUAD'f'
Watertable		CONSTRAINT	
Sur. Drain	2 levels	1:0.50 WT.	STEP'f'
Soil Type	2 levels	1:0.50 WT.	STEP'f'
Soil Depth	3 levels	1:1.00 WT.	EXPO'f'

INTERNAL SITE DRAINAGE/EXCAVATION CAPABILITY

Each of the data relevant to the study of internal site drainage capability are set out as illustrated in Figure 3. All data plot lines radiate from a common origin with terminal points located equidistant from that origin (Fig. 3a) if four data categories are to be considered; and if more than four categories are relevant a simple correction factor is made, in order to equalize the lengths of all scales.

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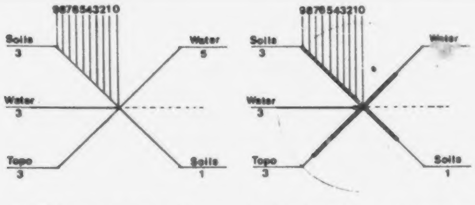
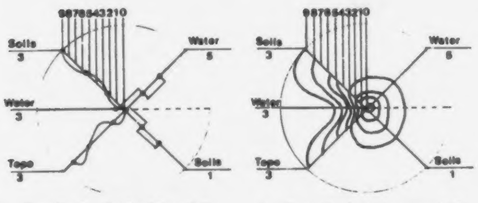


A. Variables are plotted on lines divided into ten equal units that radiate from a common origin.

B. Relative weighting of variables is achieved by shifting the terminal points towards the origin.



C. Functional relationships of the variables are plotted to approximate linear, quadratic, exponential and step functions.

D. Plotted points are connected to form a contour map of 10 levels ranging from the best condition 9, to the worst, 0.

Excellent Capability:	Levels 8 & 9	Greater than 5' of soil cover with 0-4% slope
Moderate " :	Levels 4,5, & 6	2'-5' of soil cover, 4-10% slope minor drainage, medium text soils
Poor " :	Levels 1,2, & 3	Less than 5' to watertable, less than 2' of soil, greater than 10% slope

INTERNAL DRAINAGE / EXCAVATION CAPABILITY: DATA MANIPULATION

The values or weights attributed to each of the data sets relative to the study of internal site drainage are plotted by shifting the terminal points of each data category towards the origin as dictated by the weights assinged to each of the data sets (Figure 3b).

The external functional relationships and the necessary number of internal levels of each data set are then plotted on the appropriate lines scaled to the available distance from origin to terminus (Figure 3c). The combination of the data central to a study of internal site drainage is grouped in ten levels (Figure 3d), and can be described verbally for verification and/or modification prior to being mapped either by hand or by some form of computer printout devise.

3. Design Synthesis

Synthesis of the resource potential of the study area, derived from the site capability and suitability studies, and the regional demands for development, established an open space structure for the study area. The framework is generated by positive needs for active and passive recreation, and the complementary lack of site suitability, barring major site modifications, for the range of development activities considered. The combination of these two factors, produced from an examination of the five suitability studies, provides a framework for the distribution of land use activity in the remaining zones of available land (Figure 4). Some zones are relatively suitable for all projected development activities, others are limited to a single activity; their potential and development priorities are summarized below.

ZONES:	A	B	C	D	E	F	G	H	J
Industrial suitability			1	2	1	1	2	2	2
Residential suitability	2	2		2	2	2	1	1	1
Farming suitability					3	2	3	3	3

TABLE 1: ACTIVITY ALLOCATION PRIORITIES

Due to the unique aspect of public land ownership, it is possible that the open space recreation framework might be established prior to initial development, and that it could be programmed for use parallel to, rather than following, successive phases of community construction. The framework is composed of three basic elements:

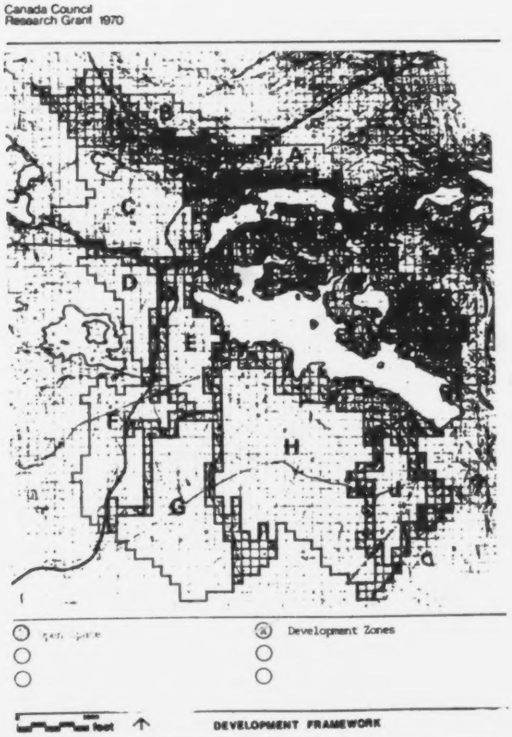


Figure 4.

a large area surrounding both Long Lake and Chain Lake, a series of recreation corridors perpendicular to the lakeside that follow the major surficial drainage course through the watershed system, and a web of open space paths that serve to connect residential areas to these corridors. Each of these elements are intended, by their physical location and characteristics, to serve complementary functions.

The large area of proposed municiple and metropolitan recreation adjacent to Long Lake ensures that all members of the proposed community will have free access to multiple-use fresh water facilities. Concurrently, this area provides a viable perceptual and natural buffer between proposed development and the water's edge. The recreation corridors are intended to support active recreation facilities for secondary schools sites, civic and social centers, as well as passive recreation activities. The open space paths provide circulation routes to primary schools, local parks and playgrounds and initiate the sequence of pedestrian movement through the future community to the corridor and lake front recreation amenities. The entire system of open space is intended to provide a means of orienting oneself within the community. Utilizing this framework, a range of land-use activities can be allocated to the study area and a

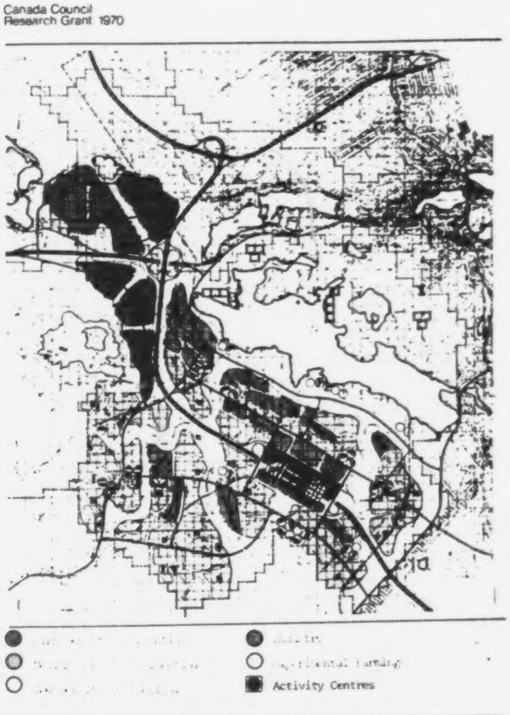


Figure 5.

variety of community structures explored. (4)

Two general allocation proposals are illustrated as a means of testing the proposed development framework and as a means of providing input into the succeeding two phases of the site planning process.

The first proposal (Fig. 5) attempts to optimize the landscape suitability of each activity zone for projected development uses. Industrial activity is allocated to zone C for light manufacturing and to zone D for research and development; residential activity is allocated to zones **E**, **H**, and J; and a tertiary sewage treatment farm, zones F and G, is projected as an experimental project which would utilize nutrient rich effluent from residential areas to support crop agriculture or tree farming (5). This procedure would require some site modifications to the topography and additional soil to increase the depth to bedrock. Soil might be drawn from the Halifax harbour or from the sludge by-product of primary and secondary treatment facilities.

Emphasis is placed on the existing system of feeder highways to provide access and egress to the community during the initial stages of growth. It is essential that the proposed regional limited access highway be located within the open space network at the boundary of the study area, which will serve to focus the local circulation and movement through the community on the recreation potential of the lakes. The planned independence of the community from the highway spine allows greater scope in the choice of growth pattern. Successive activity nodes will support each phase of development, and each can be programmed to meet new community needs or those that have not been accommodated previously. The projected population for this allocation is estimated to be 50,000 people.

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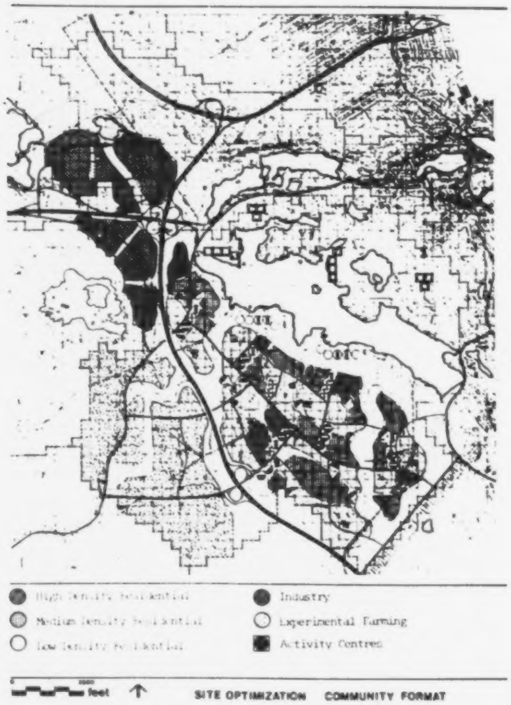

Figure 6.

The second proposal (Fig. 6) attempts to optimize external demands on the study area consistent with a modified landscape suitability format. The scheme provides for significantly larger industrial and residential allocation, and as a consequence, the tertiary sewage treatment experimental farm would no longer be viable. The proposal would require the greatest extent of site modification in order to satisfy the allocation criteria.

This scheme assumes a highway centered community structure with a regional core that would serve to decentralize the urban focus of the Halifax peninsula by creating sufficient employment opportunities and a sufficiently high level of services to compete favourably with the peninsula. The basic utilities, services, and transportation system, however, would be closely integrated with the metropolitan area.

Initial growth stems from both of the existing highways that feed the Halifax peninsula. Energy is then focused on the first phase of a regional core that will be fed by the proposed limited access highway. Succeeding stages of community development will complete the core and residential areas with options for further growth available in the land proposed for experimental agricultural use.

Local shopping and services provide the residential areas with immediate needs. Most services and shopping, however, are centralized at nodes of maximum community access. The core serves as the focus for both the community and South Shore Region with an ultimate population estimate of approximately 80,000 people.

4. Evaluation

In the Halifax study area, the activity allocation proposals illustrated include four basic costs and benefits natural, economic, social and perceptual; consequently, no uniquely best choice is described. Proposals range from an optimal demand allocation that supports only those activities that are best suited to a site within the study area, to a maximal demand allocation that attempts to allocate regional development demands to sites at the expense of other users that might be more suited to the area. Deviations from the optimal demand allocation towards a maximal demand alternative imply a devaluation of some costs associated with one or more of the data clusters and studies evaluated.

Evaluation between the two alternate structures proposed for the community is dependent in large measure on programmatic integration of those agencies responsible for the various regional service systems that must be provided to support growth not only within the watershed system but along the South Shore communities. The structure of the highway-centered community implies some commitment to a high-intensity peripheral-activity center, that will focus much of the energy of the South Shore community. The structure of the highway-bounded community disperses smaller activity centers throughout the proposed community. It is less dependent on the population catchment areas along the South Shore and more dependent on the urban core for specialized regional needs.

The pattern of growth and development within the watershed is integral with the choice of structure; both rely on the evolving pattern of primary and secondary services that derive from an integrated approach to the regional service system. The manner in which each structure grows varies with its degree of dependence upon the proposed limited access highway. Both growth patterns, however, provide a format for flexible future options.

An evaluation of activities allocated to a study area is further dependent on regional demands, the inherent characteristics of the site, and the tolerance to change that a particular site can withstand without deteriorating. Should the urban growth potential of the study area warrant development, the extent to which the pattern of metropolitan growth will be modified as the site is developed, must be assessed.

The initial allocation of activity to a study area is static, that is no change has yet been produced. However, as phased development proceeds, the recorded properties of the study area are altered and the information fed back into the data bank that described the initial conditions of the site with respect to its natural, perceptual, economic and social characteristics. The extent to which this initial data is modified is one measure of the impact of development. These impacts will be explored in phase II, User Needs, for all sectors of the data base, and the rate of change and extent of social impact assessed in order that further potential development activities may be complemented or constrained, prior to design development, phase III.

SUMMARY

A policy for stable community growth must include both diversity, a condition that is relatively insensitive to isolated development pressure; and redundancy, a condition that allows a variety of pathways for achieving a given set of personal and communal goals. The structure and organization that results from these two premises lay stress on the interpretation of activity as a multiple-use resource. An open space system, for example, might be conceived as a recreation focus, an outdoor natural laboratory, and a means of establishing perceptual orientation to the community. These activities have both formal and informal educational potential that might relate directly to the social and economic goals of a community. The overlap in interpretation and use of these activities provides the redundancy necessary for personal choice. Similar linkages can be postulated in the non-spatial realm of community organization.

An unusual measure of control is available to the government agencies responsible for metropolitan growth in the region, and in the Long Lake and Chain Lakes watershed system in particular. The element of public land ownership provides a unique opportunity to control growth within the study area. Incremental growth is characterized by small development parcels rationalized to meet immediate demands, and seldom achieves the economies of scale necessary to satisfy the pressing needs for low cost residnetial shelter and social services. Phased growth, although untested in the Region, can utilize advanced management, financial and technical skills to achieve a more comprehensive environmental mileau.

The essence of the interface between resource systems and urban growth, however, lies in the nature of the dynamic control systems available to monitor change. The management of resources exists between two extreme control situations: the categorical imperative ... thou shalt not, and complete exploitation. The first is rigid and historically ineffective, the second can be considered as absence of control. Resource management involves the establishment of a control structure that is effective as a flexible monitoring agent within a dynamic context.

Population growth tends to be gradual during early settlement; it increases rapidly as population inertia is established and major community services provided, and as the community matures the growth rate gradually decreases to a state of dynamic stability between the population and the space and services necessary to support its needs. Urban decay occurs when either element can no longer accommodate changing demands.

Unlike population growth which tends to occur as a gradual process, individual development projects are realized over a period of time, frequently as uncoordinated isolated events. Thus, development growth can be considered as a series of steps in a matrix that plots project implementation against time. The extent to which development step functions approximate the projected population growth is one measure of the efficiency with which urban demands are satisfied.

Notes

1. Jacobs, Peter, "Site Planning Process, I Activity Allocation" and "Site Planning Process, 2 Design Scheme," Noval Scotia Technical College, Halifax, Noval Scotia, 1970.

2. Jacobs, P. and D. Way, "Visual Analysis of Landscape Development," Harvard Graduate School of Design, Cambridge, Massechussets, 1968.

The perception of a landscape is frequently one ot its implicit amenities. The measure of a landscape's capacity to absorb development and the degree to which the original perception might be altered is but one means of describing an implicit value explicitly. Reaction to the perceived consequences of development typically occurs after the fact. Visual absorption measures the existing capacity of the site to absorb development in order to complement or constrain future development allocation.

Research conducted at Harvard Graduate School of Design hypothesized that the landscape has an inherent ability to screen development in varying degrees dependent on the vegetation density, topographic closure and visual complexity of the landscape in question. The hypothesis was tested by constructing a photographic matrix composed of two axes. The first represented eleven landscape combinations of the three characteristics mentioned, the second contained 15 typical photographics of land-use activity. The interior of the matrix, 165 photos, was obtained by photographically superimposing the two axes. Paired slides were then shown to a range of subjects who were asked to note on a bi-polar scale the amount to which each of the 165 combinations of developed landscapes differed perceptually from the original photograph of the undeveloped landscape. The test results were analyzed through a multiple regression programme and the hypothesis verified as report in Jacobs and Way, "Visual Analysis of Landscape Development," Harvard Graduate School of Design, Cambride, Massechussets, 1968. A summary of this study also appears in The Canadian Architect, May, 1969.

3. Hills, G.A. "The Ecological Basis for Land-Use Planning," Ontario Department of Lands and Forests, Research Report No. 46, December, 1961.

In the context of G. Angus Hills' work, capability is defined as the "inherent potential of the combined physiographic features, landforms, waterforms and their component elements, of an area for biological production." Vast areas of wilderness land in Ontario provided a laboratory for a land classification methodology which, although indirectly based on the economies of future development, was focused on the ecological potential of varying land and water types.

The concept of suitability represents "the capacity of the site in its present condition to respond to specific management practices for a particular use," and Feasibility is "the relative advantage of managing an area for specific uses having regard to its suitability for those uses under existing and forecasted socio-economic conditions.

4. Odum, Eugene, "The Strategy of Ecosystem Development," Science, Vol. 164, April, 1969.

The structure of the proposed community must recognize a range of requirements for the integration or isolation of compatible and incompatible activities, grouped into multi-use, dominant-use, and exclusive-use locations. The concept is based, in part, on the outline model and rational proposed by the ecologist Eugene Odum for the significantly larger scale of ecosystem development.

Multiple-use activities are proposed at the local scale to support diverse activity in residential areas traditionally restricted to uniform, exclusive development. Local shops, parks, social and civic facilities that derive their character from the demands directly associated with the local milieu, are assumed to be flexible in their locational needs.

Dominant-use activities are proposed at the district scale that rely on large population catchment areas for their operation and upon compatible dominant-use activities located at major access and focal points within the district for diversity and choice of activity.

Exclusive-use activities are considered as predominantly regional in scale relying on both the proposed community and metropolitan area for the necessary population base, scale economics, and level of demand for specialization.

The location of these groupings of activities is polarized to some extent by the basic network of vehicular circulation and open space pedestrian circulation proposed for the community. Multi-use activity centers for local parks, day care centers and social clubs might well be located adjacent to open space paths, whereas health clinics, social services and commercial facilities might be located along local transportation routes within the neighbourhood.

In general, as activity tends towards dominant and exclusive use, requirements of access, centralized location, and level of service become more specific and the integration of activity less feasible.

It is anticipated that a new system of land-use classification would be developed based on the perceived environmental properties, both social and physical, associated with activity that would serve to control specific allocation. Thus, research industries, as one example, might well function as part of a traditionally conceived residential district rather than its normal delegation to an exclusive-use location "on the other side of the tracks." Conceivably, these plants could serve as a viable part of the educational system in the community co-operative work/study basis that might expand the traditional range of subjects available to students of varying backgrounds and interests. Detailed programming for the community must concentrate on other synergetic benegits that derive from the coupling of activity rather than their segregation.

5. Parizek, R.R. et. al., "Waste Water Renovation and Conservation," Penn State Studies, 23, Pennsylvania State University, University Park, Pennsylvania.

The re-cycling of urban wastes has recently become a rallying point in North America. To date, emphasis seems to have been placed on solid waste re-cycling projects that drain heavily on the inherent economies of scale available in large metropolitan centers. The case study of the Halifax Watersheds, however, explores the feasibility of establishing an experimental farm based on tertiary treatment of domestic waste. Nutrient rich effluent would be piped to the site, sprayed onto the land and leached through the soil to provide fertile areas of land that might support either small crop agriculture or tree farming. The sludge by-rpoduct or primary and secondary treatment facilities might also be used to increase soil depth in those areas where there is a shallow depth to bedrock. The specific characteristics of the proposed process have been tested in a pilot project in Pennsylvania, as reported above, and an excellent historical overview of the problems of waste re-cycling is contained in Wylie, J.C., The Wastes of Civilization (London: Faber and Faber, 1959).

Acknowledgement

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A TOTAL SYSTEM METHODOLOGY WHICH DEVELOPS ENVIRONMENTS FOR CORRECTIONS

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Introduction

The lack of a universal planning and design language up to the present time is a significant cause for the lack of technological transfer between corrections and architecture. In the correctional context of the criminal justice system, any comprehensive methodology which is required must initially qualify and quantify social needs, taking into account past trends, new knowledge and change processes; it must also provide for differential routing in a complex and dynamic system, consider and develop multiple treatment modalities on several scales, develop facility networks according to output from service area survey and treatment programming design, correlate sociometric data and treatment program objectives as to their implications for the design of the physical environment; and it must provide linkages between social-physical environmental goals and the range of technological, economic, and political potentials and constraints. An interdisciplinary research team developed within the Department of Architecture at the University of Illinois and under contract to the Law Enforcement Assistance Administration of the U.S. Department of Justice has recognized these needs and has produced a versatile and adaptive instrument capable of application in a broad variety of contexts.(1)

This paper presents the goals of the interdisciplinary team's research. Then it describes both the methodology employed for the research and the methodology embodied in the research result (entitled Guidelines for the Planning and Design of Regional and Community Correctional Centers for Adults.) Finally, it furnishes a description of the implementation process already operational.

The research goals of this work are several. The first of these involves the recognition that the testing of theories requires the development of tools, methods and means of communication. Particularly, emphasis in this effort is directed towards the development of knowledge and tools which are viable resources in the resolution of the problems of society. Due to the form the research result took, and to the vehicle which is established for its broad implementation, both reproducibility of research is possible as well as the feedback of results. Flexible and responsive to widely varying needs in its contents, the Guidelines for the Planning and Design of Regional and Community Correctional Centers for Adults also develops a methodology that establishes the criteria which must be met for the funding of correctional facilities under the Part E Amendment to the Omnibus Crime Control and Safe Streets Act. Further, the designation of the interdisciplinary research team as the National Clearinghouse for Correctional Programming and Architecture provides the team with a significant opportunity for the evaluation of implementation results, continued vehicle and content development, and it also serves to provide others with a reference point for the accumulation and transmission of new knowledge. We find an overwhelming confirmation of a need for a rational and comprehensive planning process which generates environments for corrections. The Guidelines are currently being utilized at the level of total state system planning, regional and multi-county planning and at the most local levels of planning and design. Its process is employed sequentially and cross-sequentially, as a check against previous ungrounded projections, and as a communications device which gives direction to pluralistic decision-making.

As evidenced by the composition of the research team, which includes architects, sociologists, lawyers, and economists, with consultants in criminal justice administration, correctional program development, counseling, construction technology and other areas, this endeavor is problem-oriented rather than object-oriented.

The problems of the American correctional system to which the design methodology addresses itself are multiple and pervasive. The fact that corrections represents a convincing case of failure is acknowledged by practitioners and scholars alike. Recidivism, which may be defined as the repetition or recurrence of delinquent or criminal conduct, is unquestionably high. Because of an almost unforgivable absence of systematic tracings of released prisoners from jail and penal institutions, there is considerable debate about precise failure rates and it is safe to assume that, if the correctional system were required to operate like any other business enterprise, it would have gone bankrupt a long time ago.(2) Further evidence on the inefficiency of the correctional system is accumulating, and it shows the undesirable and derogatory effects exerted on prisoners by a correctional environment which seems to compound the very problems it professes to treat. This situation is particularly aggravated in jails, where a considerable proportion of persons arrested for serious crimes are released without charge or on minor charges only, and where another sizeable number of those who are convicted are placed on probation. (3) If we realize that, when compared to state penal institutions, most jails operate with insufficient funding and sub-standard and often sub-human physical conditions, we are faced with the further dire realization that we often treat those presumed innocent until proven guilty worse than convicted offenders.

In recognition of these inequities, an all-out effort to improve corrections has been launched in the last few years. The movement started with the passage of the Omnibus Crime Control and Safe Streets Act in 1968, and it received additional impetus through accelerated federal funding under Part E legislation of an amendment to that act in 1970. One of the most notable trends in this quest for improvement has been in the direction of community-based corrections. Under this concept, the acknowledged task of corrections, namely, the restoration of the offender to the status of a fully participating and contributing member of society, takes place at the site where the problems originate. Instead of being isolated even further from his community, as occurs in geographically isolated penitentiaries, the offender remains close to family and kinship ties. Further, rather than being treated as an outcast from society, the offender is treated, as much as this may be possible without detriment and danger to the community, within the community environment, the disorganization of which having been recognized as contributive to his delinquent behavior. As a result, focus is concentrated on changing the offender as well as the community, hopefully to the benefit of both. Other advantages lie in the fact that educational and social services need not be duplicated in expensive institutions but can be utilized on location and to the degree needed; programs of transition, such as work-release, graduated release, and residential programs can be provided with reduced cost and effort; and finally, individualized treatments and programs are easier to administer when they are based on the recognition that widely differing offender types will require a corresponding variety of treatment approaches.

Outdated correctional practices are perpetuated by obsolete facilities. The power which architecture has traditionally exerted upon correctional programs or upon any activity taking place within prisons is evident. Unfortunately, not only have offenders repeated their mistakes after leaving outdated institutions, but likewise the program and facility which failed to rehabilitate the offender have inexorably been repeated at yet another location. The recognition of this fact by the recently created Law Enforcement Assistance Administration and its Ad Hoc Committee on Correctional Architecture led to the research assignment at the University of Illinois.

In developing an approach which would produce the kind of comprehensive planning instrument required, several reference points were established and criteria evolved by which any decisions would be evaluated. First was the understanding that any instrument which sought to encourage and accomplish change in a dynamic system must be capable of change itself. Accordingly, the ultimate development of this instrument proceeded in an open-ended structure. The capacity exists for addition or subtraction in every section within a looseleaf format. As a mechanism for servicing this potential, the National Clearinghouse is already operational. Further, in order to be both comprehensive and specific, it was determined that individual usage would take the form of self-selected pathfinding according to the applications of each step to the problem context. Thus, no single models, programs or packages are developed by the Guidelines, nor are any replications developed by misapplication. Solutions in correctional programs and facility planning and design are determined through application of process to problem.

As further background to the development of a design methodology which creates environments for corrections, a discussion of its intended and anticipated users is appropriate. Assessment of the existing attitudes, operations, responsibilities, and process roles of a wide variety of participants provides the research team with significant determinants to instrument design. Participating in such discussions are architects, planners, correctional planners and administrators, correctional staff and clients, management consultants, jurisdictional government officials, planning agency staff, funding agency staff and lay citizenry. Previous efforts to develop widely applicable design methodologies or "languages" have fallen upon difficulty in not fitting, in the instance of architects, "design behavior." The methodology contained in the Guidelines encompasses a broader scope of analysis and synthesis than is normally engaged in by architects. The reason for this lies in its orientation to problem solving on an extremely comprehensive basis rather than to the usual confines of their discipline. Nonetheless, the methods and concepts are communicated by symbols familiar to architects. Organization is structured according to action sequences normal to design activity. Additionally, sectionalization clearly indicates

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the scope of specific concerns and their relationship to later decision-making. A common planning process is offered with respect to participants other than architects in the policy, planning and design-making process.

Given conditions for action are the existing setting in all of its dimensions, social, physical, and political. Crucial to application and implementation of a change-oriented process and concepts is the ability of the user to make linkages with present realities. Accordingly, the methodology focuses first upon such conditions as are given. Factors which suggest change are identified and advantages and disadvantages compared. Significant in the analysis of prevailing planning practices in corrections is the finding that they have not been correlated to planning in other sectors which have major impact upon them. Thus, the prevailing deficiencies of architectural planning in corrections, which often have produced competent solutions for mis-stated problems, have a corollary in correctional planning which has, for example, attempted to process the treatment of individuals who should not be in the system at all. In each instance, there is the need to consider problems in a broader context and to approach their resolution in co-ordination with other theoretical, functional, and jurisdictional components. This strategy is taken by the Guidelines as the only promising means of optimizing the total system performance. The user, who is pluralistic and currently fractionalized by vertical and horizontal functional separations, is integral to this methodology. The planning instrument developed for use in this process brings together the separate sectors, including those of community law enforcement, courts, corrections, community service agencies, the social sciences, and the environmental design professions; it furnishes these sectors with a common action strategy for a multi-factored analysis and effort aimed at problem resolution.

Research Methodology

Recent developments in the social sciences have demonstrated that no single research methodology is entirely without bias. For example, overreliance on interviews and questionnaires, traditionally the staple instruments for data collection, may jeopardize findings if they reflect personal or situational factors which may be either transient or totally irrelevant to the research question. This kind of criticism is, of course, equally applicable to the other research methods available in the arsenal of the sciences, such as participant observation, projective techniques, case and record studies, and analyses of physical traces. As a result, "multiple operationism" was selected, in which a collection of methods is combined and brought to bear on the research topic; this approach is based on the premise that, if a proposition can survive the onslaught of a series of imperfect measures, with all their irrelevant error, confidence could indeed be placed in it.(4) In an effort, therefore, to utilize the best possible research tools, the following classes of measurement were chosen:

1.1. The observational method, which constitutes the primary tool of scientific inquiry and serves primarily at the formulative stages of the research process. For example, in an effort to sensitize the research team to the multiple needs of the correctional system, a strategically designed and systematically planned exposure to the varying types of correctional facilities was undertaken. Systematic recording of observations by team members occurred on field-tested fact sheets, which were continuously subjected to checks and controls on concept validity.(5) Among the advantages of this methodology is the fact that behavior can be recorded as it occurs, data can be obtained independently of a subject's willingness or ability to respond, information can be collected on typical life situations as well as on items either deliberately or inadvertently withheld from annual reports or official accounts issued in writing.(6) Among some of the limitations of this method we find, for example, that it is difficult to predict and thus observe the unusual occurrence of events, events which like riots may significantly affect social and physical environments. Further, certain events may not be observable due to their intrinsic nature, as for example inmate witnessing of deviate sexual assaults. And finally, the technique is limited by the time element on the part of the observer, as well as the observed. During the research process, unstructured, flexible, and exploratory observation became increasingly defined and structured with the tracking of participants, functional relationships and physical environment.

1.2. Interviews. Next to empirical observation, the interview is considered to be the single most flexible research instrument. It is particularly useful in the assessment of complex, emotionally laden subject matter, as well as for the probing of sentiments underlying expressed opinions.(7) As a result, the interview offers a singularly good opportunity to appraise the validity of research findings in the area of corrections, which characteristically are fraught with nuances and subtleties particurlarly in the area of general philosophical orientations, which function as guiding maxims for agencies and institutions. For example, while annual reports may embrace the latest, most enlightened treatment philosophy, a skillfully conducted interview will easily lay bare the prejudices and motivations, still so pervasive in our society, which underlie actual punishment practices. Among the recognized deficiencies of the interview method, however, is the

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language barrier problem which becomes particularly acute when those interviewed are of a different social class than the interviewer. As a result, while interviews with administrators and higher echelon staff in corrections presented no particular problems, research results based on interviews with inmates and lower echelon correctional workers warranted special consideration.

Differences in status characteristics, in particular, have been singled out by past research as tending to exert biasing influences on the information elicited from respondents.(8) It was found, for example, that racial differences and the social distance between interviewer and respondent, as well as the threat potential of interview items, were highly associated with bias. There can be little doubt that research in corrections is particularly vulnerable to this bias. It speaks of an almost incredible naïveté on the part of any researcher to assume that inmates will bare their souls during a one-shot visit, even if he carefully couches his entrée in a vocabulary antagonistic to the system. For inmates, rule number one will prevail: they want to get along in a generally hostile social and physical environment which will continue for them long after the researcher is gone. As a result, it is best to weigh such findings in the light of available scientifically conducted studies. The next class of measurement is discussed below.(9)

As far as the types of interviews used were concerned, the non-standardized and focused interview was favored at the beginning of the research process in order to facilitate careful exploration of the issues. At a later point, non-scheduled standardized and scheduled standardized forms were utilized to assure comparability of findings and accumulation of responses to various research questions, with each being checked for construct, predictive, and face validity, as well as for reliability.

1.3. Utilization of available data, records, and research materials. We indicated previously that no single technique or research tool can be considered adequate enough to warrant finite conclusions. As a result, triangulation of the measurement process was used in the development of the Guidelines, so that maximum confidence could be placed in the research findings. It was here that interdisciplinary input into the research process assumed a key function. It must be recognized that, although corrections is still an unknown quantity as far as the average citizen and lay person is concerned, considerable knowledge has accumulated in the field, which constitutes a branch of criminology and a recognized substantive area in the discipline of sociology. In view of the fact that the treatment of offenders has historically been and continues to be motivated by a combination of such feelings as revenge and retribution, religious ardor and philosophical idealogies, as well as changing theories regarding the etiology of crime, careful selection from this accumulated knowledge, in terms of its utility for the research process, assumes a vital role for a project's success. Empirically verified facts need to be separated from theories, correlations from causal factors, and assumptions from hypotheses. Research processes without such careful differentiation and guidance are bound to be inadequate; witness the dismal failure of the "Pennsylvania system," the Quaker inspired prison pattern based on an ideology which deemed single occupancy cells and the absolute isolation of prisoners the environment most conducive to the spiritual reformation and rehabilitation of the offender. Similar reasoning produced the Auburn system, the monolithic architectural remnants of which still haunt us today. As far as architectural research design is concerned, however, it is necessary to point out that direct application of the findings of social research to the design process is frequently fraught with difficulties, and occasionally quite impossible, because few research pursuits by the disciplines have heretofore included architectural effects as dependent variables. While in the past most scholastic pursuits in penology have concentrated on the etiology of criminal behavior and the types of measure which might countermand the activities of persons defined as criminals, studies of recent endeavors emphasize societal reactions to crime, such as the processes of definition and the institutions designated to deal with offenders. With few notable exceptions, therefore, physical environment has always been treated as a "given." Yet another difficulty in the application of social research to the design process needs to be discussed. Just as environmental design professionals have developed various descriptions of process and effect intended to facilitate the communication process, so have the social sciences developed a wealth of concepts and constructs which describe abstract and complex qualities of groups of variables not directly observable. Such logical tools are vital to the research process and necessary for operationalization, yet they are difficult to translate. As a result, interdisciplinary interaction requires careful sensitization of participants in terms of their shared concerns.

In summary, the research methodology in the development of the Guidelines assumed that each particular research method has built-in biases concerning the types of data and types of hypotheses it can accommodate. This weakness in any one method will, therefore, bias any study relying upon such a method.

Since social reality has many levels and can be approached from a number of different perspectives, any method representing only one such approach in effect measures only one category of relevant factors. A single method design over-structuralizes and over-simplifies the process at hand. Therefore it is desirable to attack any problem from a number of angles, to let various methods test that for which they are best suited, and to let our results represent the overall effect of the various methods upon our interpretation.

Core knowledge provides the basis for problem definition, potential resources and hypotheses which, if tested, promise to contribute further to core knowledge through either positive or negative findings. Through the process of controlled and measured testing, assigned to Zone 4 in Figure 1, results of recorded experience develop new information in which tentative or marginal levels of confidence can be placed, as in cycle Ⓐ. Repetition of such testing over extended periods of time and in varying contexts may either return the findings to the zone of "no confidence" (Zone 4), as illustrated in cycle Ⓑ, or successively reinforce the hypothesis and move the theory to higher levels of confidence, as diagrammed in Ⓒ. Ultimately, this cycle has the potential of leading to new contributions to core knowledge.

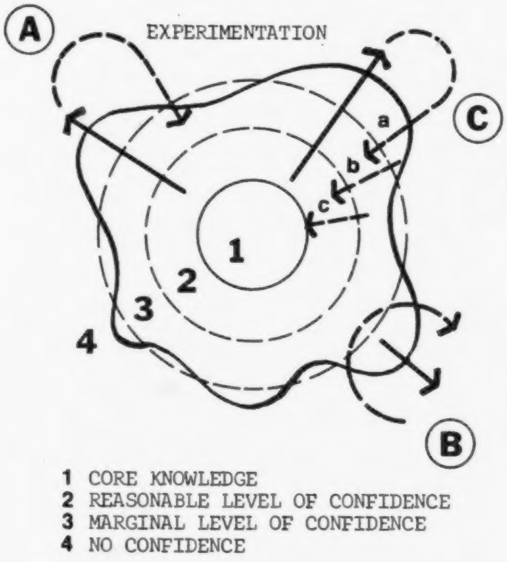
A
EXPERIMENTATION
C
a
b
c
1
2
3
4
B
1 CORE KNOWLEDGE
2 REASONABLE LEVEL OF CONFIDENCE
3 MARGINAL LEVEL OF CONFIDENCE
4 NO CONFIDENCE

Figure 1

Core knowledge, as used in this discussion, is defined as the summary of available knowledge of the relationship between properties in more general terms than the empirical findings on which it is based. In the area of corrections, the bulk of the measurable experience has been defined as failure. Accordingly, a significant portion of the core knowledge includes the definition of what should not be done. Nonetheless, negative results offer substantial grounding for new hypotheses. The Guidelines takes cognizance of this situation, and provides an instrument which presents action strategies grounded in reasonable levels of confidence, if not core knowledge. In the area of environmental design, the core knowledge of correctional architecture, as derived from experience, is even more negatively oriented than it is in correctional programs. Grounding for the Guidelines' hypotheses in this area has come both from the numerically and relatively smaller instances of positive (supportive) correctional environment, and more substantially, from the analysis of other core areas. For example, the recommendation for educational activity in the correctional program structure is served by examination of that knowledge of learning environments outside of corrections which can be considered core or regarded with reasonable confidence. Such knowledge is considered in the correctional context where, for example, wide variation in educational attainment exists and attention has to be given to individualized and self-pacing teaching approaches. Experience with these concepts has been confined for the most part to our educational systems, with little work being done in the field of corrections. The same illustrative model applies to a wide variety of program activities which are recommended in the Guidelines for corrections and about which the prevailing body of knowledge has been derived in other institutions. A certain measure of the transference of core knowledge from other areas to corrections, with respect to environments, constitutes an hypothesis, but one in which reasonable confidence can be placed.

Guidelines Methodology

Traditional environmental design methodology in corrections typically includes in the research process visits by the architectural firm to several facilities, generally of the type and caliber intended to be built. Detailed planning involving such things as facility size, type of hardware, functional spaces, etc., generally depends upon information obtained from administrators who are involved either directly or indirectly in corrections. In recent times, a number of valiant forays have occurred in the area of "one shot" inmate interviews, in spite of the obvious shortcomings connected with such a methodology. Because of such research procedures, completed projects are inclined almost invariably to become oversized, featuring too much hardware and including populations, which according to current best estimates, are not the proper targets for

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the correctional process. Additionally, even the selection of facility models to be visited is likely to invite or display prejudice towards the ultimate product of the design activity, and the paucity of successful models limits further the effectiveness of this kind of approach. At the investigative stage of the design process, preoccupation with solution rather than problem and with product rather than process is characteristic of traditional design behavior. An understanding of the problem is not delivered by a limited and superficial analysis of previous physical or social solutions.

In order to provide the correctional planner, administrator, and architect with an appropriate methodology and suitable tools for the planning and development of a viable and effective correctional complex, comprehensive survey instruments were developed to facilitate the systematic collection of data from a target population. Since one of the intrinsic advantages of the survey technique lies in the fact that it can be applied to any population size, the instruments featured in the Guidelines are therefore applicable for state level correctional planning, regional planning, and finally, local level planning.

Furthermore, in an effort to go beyond traditional and conventional planning, the survey instruments reflect the total systems approach embraced by the Guidelines, in that they involve the entire Criminal Justice System in the data gathering phase. This approach recognizes that meaningful change in a largely stagnant and ineffective corrections sub-system can only come through the effective involvement of and changes in the other sub-systems, namely, the law enforcement branch and the judicial system. As a result, a field-tested survey instrument package was developed, featuring the following components: (1) a correctional system inventory, which assists the planner in identifying the correctional problems of the geographically defined target area and which inventories current and past correctional practices. (2) A judicial system inventory, which identifies current and past judicial practices, as they pertain to criminal law cases. In particular, sentencing trends are uncovered in terms of increased or decreased use of incarceration on the part of the judiciary, as well as fluctuations in the numbers, types and seriousness of offenses. (3) A survey component reflecting Uniform Crime Report trends, as well as population fluctuations from the Census Bureau, rounds off the statistical survey of the Criminal Justice System.

Early in the research process, however, it was recognized that comprehensive planning in corrections would need to go beyond the Criminal Justice System complex, in order to bring about truly innovative changes in the disposition and treatment of offenders. It was as a result of this that the second major input from the behavioral sciences came into the research process. Stated briefly, there is increased recognition that crime is as much an indication of individual failure as it is symptomatic of the failure and disorganization of the community.(10) Next, there is an accumulation of evidence pointing to the fact that many detention facilities, particularly on the city and county level, are holding large numbers of persons in pre-trial detention for reasons of indigence rather than for the protection of the community. Needless to say, such persons are overwhelmingly members of minority groups, with limited powers and recourse. It is this population, in addition to other offender categories, which is identified through the correctional systems survey, so that subsequent program planning can include a systematic provision for more equitable dispositions.

Finally, there is overwhelming evidence that most correctional systems today are forced to deal with certain categories of "offenders," which are not the proper metier of corrections, and which have been recognized as social-medical problem cases instead. As a result, adequate planning would divert such cases as the alcoholic, the drug addict, the feeble minded, senile, diabetic, epileptic, the mentally ill, the nuisance sex offender, the homosexual, the vagrant, the skid-row personality, etc., to existing community resources, which are characteristically better equipped to handle them. To facilitate such diversion techniques and to maximize the enlistment of community resources in the total planning process, a fourth survey component was developed, for the purpose of surveying such resources as alternate routing and treatment schemes.

The multiplicity of information sources in the survey area has further advantages: first, the great diversity in the quality and quantity of available statistics in various jurisdictions demands information input from various sources to achieve the kind of triangulation of data discussed earlier and to warrant confidence in the planning conclusions. Second, information on a large number of variables yields itself to factor analysis and other multivariate techniques. In factor analysis, for example, a large number of intercorrelated indices can be taken and reduced to a smaller number of underlying conceptual variables or factors which are strongly related to them. Inferences as to the correlations can then be made and fed into the planning process. Multivariate analysis is particularly useful in social research, since it facilitates the analysis of systems of relations, interaction over a period of time, and the reproduction of the complexity of social phenomena.

To facilitate data processing and computer simulation, the response categories on the survey questionnaires have been precoded with statistical summaries and program linkages providing for data projections. The results identify for each target area the theoretical minimum of offenders for whom detention facilities must be provided, the theoretical maximum of offenders for whom alternatives to incarceration may be utilized, the capacity of community resources to absorb non-anti social "offenders," and the type and number of correctional programs that would be needed for an improved correctional process.

In view of the fact that the planning solution for a particular target area is based on specific statistical input from that area through the survey process, a well fitting and tailor-made plan is virtually assured.

Another important but heretofore neglected aspect of the planning process concerns offender classification. Classification provides administrators and planners with the necessary tools for decision making in a number of ways: first, from a treatment viewpoint, classification systems and typologies attempt to explain and predict behavior in an effort to provide a

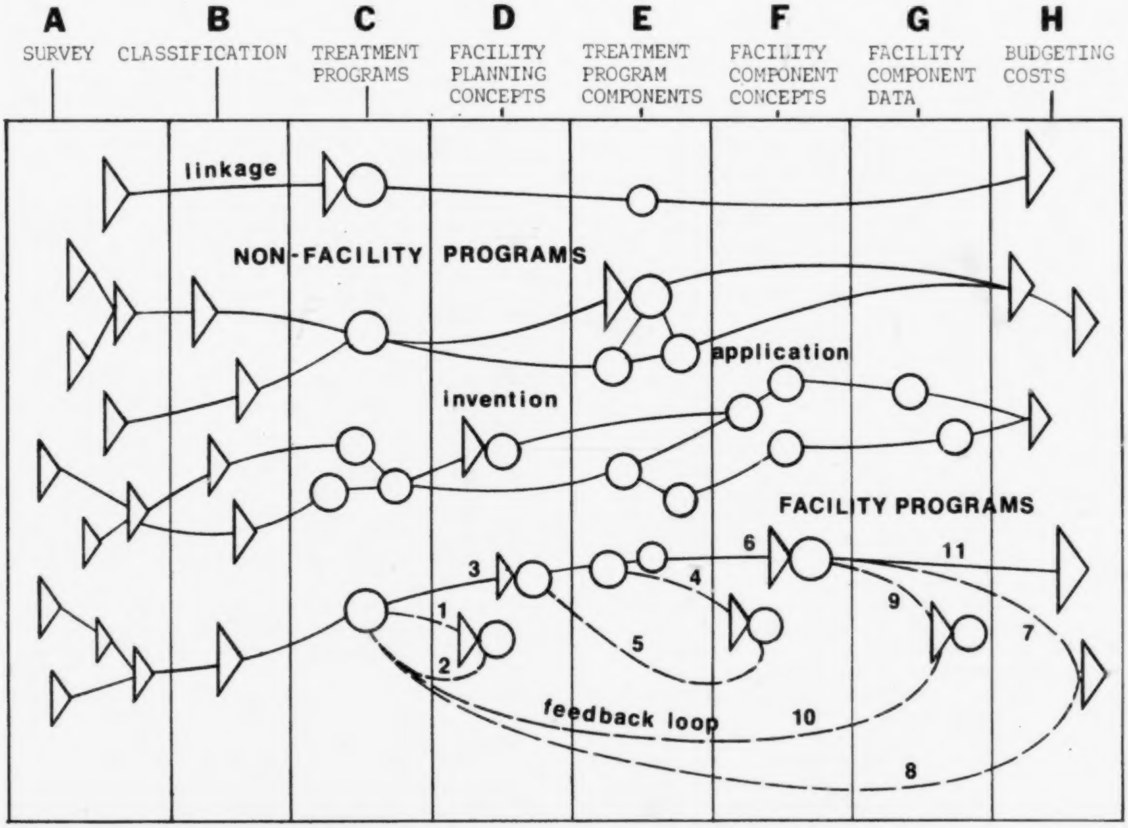

A
SURVEY
B
CLASSIFICATION
C
TREATMENT PROGRAMS
D
FACILITY PLANNING CONCEPTS
E
TREATMENT PROGRAM COMPONENTS
F
FACILITY COMPONENT CONCEPTS
G
FACILITY COMPONENT DATA
H
BUDGETING COSTS
linkage
NON-FACILITY PROGRAMS
application
invention
FACILITY PROGRAMS
1
2
3
4
5
6
7
8
9
10
11
feedback loop

Figure 2 **GUIDELINE USAGE DIAGRAM**

▷ = ANALYSIS ○ = RESPONSE (application) ▷○ = ANALYSIS/RESPONSE (invention)

The various sections of Guidelines content are diagrammed in Figure 2, in conjuntion with a network illustrating the multiple sequences of analysis and actions which are involved. In response to contextual needs, an infinite number of paths are possible.

foundation for particular treatment techniques. Even though the development of classification processes is still in its infancy and various approaches practiced on county and state systems are in dire need of empirical verification, classification does function to protect correctional programs from such embarrassment as riot, disorder, or escape, and it assists in the description and classification of existing institutions. The second purpose of the classification process is even more vital in the early stages of the design process, whether it pertains to new construction or to the renovation of facilities. Classification provides the planner with the raw data not only for the determination of population sizes, but also for the levels of security that will be required.

The third approach to classification views it as a comprehensive process: in the course of this process, an offender reaches a number of points at which important decisions are made; each decision determines his future from that point on, and each decision has crucial implications for the program and facility planning process. In this respect then, classification processes are used to keep as many offenders as possible out of correctional institutions by shunting them, wherever feasible and without endangering the community or themselves, into a number of practicable pre-trial dispositions intended to relieve the pressure of burgeoning jail populations and to keep the frequently dehumanizing effects of incarceration at a minimum.

While the survey process assesses correctional practices, offender profiles, and community resource potential; and classification systems provide information in terms of diversion techniques, security requirements, and population sizes; the treatment program section of the Guidelines features a full range of programs for a vast variety of offender categories, as well as program dispositions in terms of alternate routing and treatment schemes. A deliberate division is made in the programming between alternatives to incarceration and those programs requiring facility components. In fact, since it would be fallacious to assume that any one program could be appropriate in any setting, a range of equivalent programs in each category is offered. Each type is presented in an ideal form, with an hypothesized program size to indicate optimal staff/client ratios and program component selection, as well as cost analysis information. The programs offered for choice were selected on the basis of the best available information from innovative programs operating within the country today.

Among the range of programs involving facilities are those designed to treat the convicted offender in a variety of settings. For example, if classification deems it appropriate, certain misdemeanants and even felons may be more suitably treated in residential treatment programs rather than in a conventional jail or state institution. In each case, the offender is matched up with an appropriate program, one based on an assessment of his individual needs paired with society's requirements for protection. The facility/program range covers relatively "open" residential living, intermediate types characterized by increased structural supports, all the way to post-trial security programs designed to provide carefully controlled physical environments and programs for the control and treatment of the serious predatory offender. In addition, a series of facility/programs are featured, which are specifically designed to treat the socio-medical problem cases that currently account for much of the revolving door syndrome in city and county jails. In particular, residential programs for the alcoholic and the addict are featured, in combination with the appropriate police disposition programs without which such alternative routing schemes could never function.

Throughout the planning process, it is stressed that none of the programs should be considered as functioning in isolation; rather, they should always be evaluated in terms of networks of correctional programs, in order to assure the development of the best possible correctional service plan.

The principles operational in the design process may be identified and linked to decision-making as a result of specific factors which are recognized in an analysis of the problem and which confirm one course of action to be more rational than another. Principles may also be identified and inventoried separately from active problem-solving but in association with the conditions which produce them. In this instance they are linked to problem solving by the comparison of conditions. In order to provide maximum versatility in application and usage, the Guidelines employs both strategies.

Throughout the discussions of the various treatment programs, verbal and graphic means are employed to describe the correlations of behavioral objectives to environmental implications. Extensive labeling and diagramming are used in conjunction with the treatment text to describe desired conditions of social interaction which generate the requirement of generic qualities, quantities and relationships of space. Consequently, the earliest discussions of treatment issues, objectives and programs are linked to considerations for the physical environment. Particular emphasis is directed to such linkage in view of the research team's finding that the bulk of our correctional programming and architectural legacy makes no such connection. That the present system has failed to make such a connection is, in large part, responsible for the failure of this system.

Among specific examples of socio-environmental relationships, offered only for the purpose of illustration, is the recommendation that individualized treatment efforts be supported by correctional environments which offer the resident personal space or individual territory; that treatment programming which intends to encourage the development of normative behavior patterns take place in an environment which more closely replicates a normative environment for a diversity of functions, such as sleeping, dining, recreation, visiting, etc.; that programs which seek to attain community involvement with their activities be supported by a physical design which provides easy accessibility and exposure to such programs; that community treatment is preferable to institutional treatment in most cases and can be implemented without detriment to the community involved; that varying client needs require ranges in environmental characteristics for program flexibility in meeting them; that support for structured and unstructured individual and small group treatment activities be given by smaller spatial increments; that the provision of normatively scaled activity spaces within correctional facilities anticipate offender return to the "outside" and support his reintegration; that the identification of clusters in residential facilities provide the resident with a reference place and reinforce his self-identity; that re-integrative program objectives be served by facility design which achieves a character integrated into the community physical context; that client involvement with formal or informal program activities be increased by structuring movement patterns in such a manner as to provide exposure to them; that programming which seeks to develop responsibility and independent decision-making capabilities on the part of the client be supported by a physical environment which allows for degrees of choice-making and self-expression; that treatment programming which is grounded in communicative processes be supported by a physical environment which is considered as a treatment component in itself and as a means for assistance in the communication of values, attitudes and potentials to the offender; and a wide variety of other considered relationships which can, for the purposes of discussion, be designated principles. The foregoing illustrative listing is by no means a complete representation of Guidelines content, nor is it in hierarchial order. The list does indicate, however, certain concepts connected to early program planning activity in the discussion of specific treatment programs. Such programs include Judicial Intake, Diagnostic, Alcoholism Treatment, Narcotics Treatment, Mentally Ill Offender Treatment, Residential Treatment, Work-Educational Release, and others. Since the manual is structured according to specific treatment activities and program components, design action recommendations occur in that context and forward references occur for more specific environmental concepts and data.

In recognition of the fact that similar phenomena in socio-environmental relationships develop in what would conventionally be considered different treatment settings, an alternative treatment of issues was developed to avoid the exclusive associations which might otherwise develop between specific programs and more generalizable concepts. This technique involved an independent discussion of factors which are designated in the Guidelines as "facility planning determinants." The intent of this section is to provide a systematic basis for making required linkages between needs and solutions. As illustrated in Figure 3, the format utilized is a data-sheet organization providing for source, context, "if" condition, "then" result, together with a discussion.

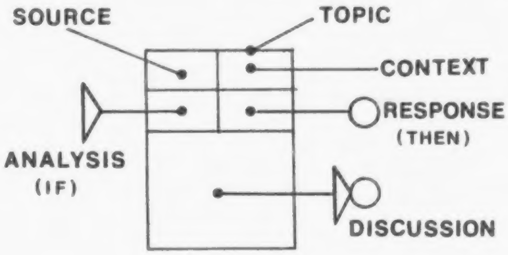


Figure 3

Determinants considered include location, site context, function, identity, scale, security, administration, flexibility, climate, construction technology and economics. As in other sections, pagination and organization is open-ended to allow for additions to this resource area. Its particular orientation is to the earlier conceptual phases of the environmental design process, with the recognition and expectation that the level to which specifically cited determinants will be influential in a planning and design development process will be analyzed and evaluated in conjunction with other determinants which also are found to be integral to the problem context. The examples offered are intended to help build a common vocabulary and programmatic focus for the correctional administrator and the facility planner.

Like the initial survey section, which develops an analysis of criminal justice and community needs and resources in terms of a service or target area, the facility planning is introduced in the context of particular target areas. Again, the generic model is used, so that the planner and administrator will identify their general context within the range of the examples which are discussed. For these purposes, the illustrations of Urban Networks, City-County Networks, and Multiple-County Networks are developed. Particular emphasis is placed on the view that facilities are supportive elements to the delivery of diversified correctional treatment services in a service zone. In their qualitative and quantitative dimensions, the specific programs as well as the resultant facility programs emerge as part of the output of the survey and classification activities. For each illustrative network, the target area is verbally described, and assumptions regarding projected populations, court facilities, and program linkages are made explicit. Upon this basis, the concept of the network approaches to the delivery of services is examined. Various facility types which the hypothetical network would generate are diagrammed in terms of relationships of funtions in single-purpose facilities and in multi-purpose facilities. The intent of these diagrams is to show how, utilizing facility planning determinants as "rules," various treatment components can be combined into facilities which respond to specific needs of a target area.

As the definition of treatment programming becomes explicit and its various program components identified, linkages are made to ranges of environmental settings by verbal and graphic description. Characteristics are clearly stated. The intent is not to limit alternative design solutions, but rather to provide a definitive statement of generic environmental characteristics. Cross-referencing links facility component data sheets to appropriate treatment program component discussions. Ranges in program objectives and the policies which serve them generate ranges of environmental conditions, from normative to specialized. The component design approach is utilized to allow for great diversity in assembling possibilities. Also, it allows for an approach to the renovation or conversion of existing facilities which compares desirable characteristics to those which exist by utilizing program activity as the common denominator. Assessments of existing facility potentials can be made by measuring their deviation from these generic and specific ideal conditions. Ranges of facility components are presented in thirty-two categories of functions which are generated by treatment programming.

In response to the fact that design decisions concerned with building material selections, furnishings, equipment, special features, and other issues are of critical importance in determining the character of the environment which the user will perceive, a section of the Guidelines is devoted to facility component data. In addition to material selection criteria which are matrixed with categories of functional components, individual data sheets offer supportive information for a variety of functions.

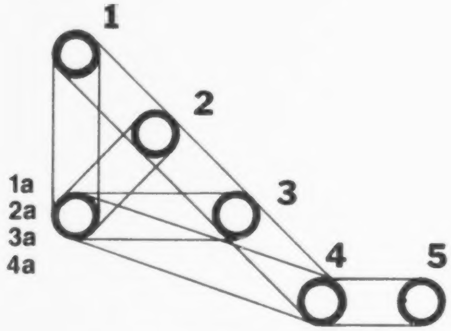
Finally, budgeting information on a wide variety of correctional programs is presented, including staffing, facility and planning costs. The user of the Guidelines is provided with information which allows a general assessment of the relative costs and effectiveness of these programs and also with an identification of the variables involved in interpreting and developing costs data pertinent to his requirements. Also, worksheets are included which provide methods for projecting staff and facility budget requirements. Extensions of these materials currently being developed include additional data sheets which offer treatment program profiles together with anticipated per-client costs. This supplement is oriented to early budget projection activity and does not supercede or replace other more detailed methods of costs projection which are also included. The cost comparison between general program types, with variances in amounts of program support space and differentiation in levels of security, will likely be influential in gathering support for progressive community-based programs.

Conclusion

Basic to the evaluation of the effectiveness of a design methodology is the measurement of the instances of its application, and basic to the success of any methodology is its ability to respond to the results of such evaluation. Guidelines has both capabilities, because of the implementation process provided and because of the characteristics of the planning instrument itself.

Funding for the Guidelines is provided as a result of special conditions attached to planning funds by the Law Enforcement Assistance Administration, United States Department of Justice. Such funding, under the Part E Amendment to the Omnibus Crime Control and Safe Streets Act, requires that correctional facility planning and design support rehabilitative treatment programming. This intent is established in the Congressional legislation itself and in the research contract which produced the Guidelines. Accordingly, the application of the Guidelines planning process has been built into a vast number of instances of service areas of varying scales, demographic profiles and other regional variations. Due to the overwhelming need for a comprehensive planning process in this problem area, the Guidelines concepts are also being implemented in a vast number of additional instances. The research staff is attaining equal levels of contact in these situations. Feedback of implementation results is structured by the staff in this process. As the National

Clearinghouse for Correctional Programming and Architecture, the research team is provided with significant opportunity to collect and transmit vital data.



1. SERVICE AREA PLANNING
(Community, County, Regional, State)
1a. NAT'L Clearinghse. Technical Asst.

2. STATE PLANNING AGENCY REVIEW
-incorporation into State Plan
2a. NAT'L Clearinghouse Tech.Asst./Review

3. LEAA REGIONAL OFFICE
-State Plan Review/Admin. of Funding
3a. NAT'L Clearinghouse Tech. Asst.

4. LEAA, Washington Office
-Co-ordination/Congressional Liason
4a. NAT'L Clearinghouse Research, Guidelines Dev., Evaluation.

5. CONGRESSIONAL APPROPRIATIONS

Figure 4

With respect to the adaptability of the planning instrument to future change, it has already been shown that this capability was a significant determinant for the instrument's design. It is open-ended in structure, having a looseleaf format and a pagination system which permits additions or deletions to any index topic, as well as to any sectional index. The further capability exists to combine only those sections or data sheets which relate to the perceived needs of a specific planning area at the particular time of use. Increased responsiveness to local need is provided and has already been utilized.

In total, the methodology for the development of correctional environments presented by the Guidelines for the Planning and Design of Regional and Community Correctional Centers for Adults represents an effort to meet the diverse needs of society in a complex problem area.

Notes

(1) Moyer, Frederic D., Dr. Edith E. Flynn, Fred A. Powers and Michael J. Plautz, Guidelines for the Planning and Design of Regional and Community Correctional Centers for Adults.

(2) See Glaser, Daniel, The Effectiveness of a Prison and Parole System (Indianapolis: The Bobbs-Merrill Co., 1964), pp. 13-35.

(3) Task Force Report: Corrections, The President's Commission on Law Enforcement and Administration of Justice (U.S. Government Printing Office: Washington, D.C., 1967), pp. 72-81.

(4) Webb, Eugene J., Donald T. Campbell, Richard D. Schwartz and Lee Sechrest, Unobtrusive Measures: Nonreactive Research in the Social Sciences (Chicago: Rand McNally & Co., 1966).

(5) Blalock, Hubert M., Jr., Ann B. Blalock, Methodology in Social Research (New York: McGraw-Hill Book Co., 1968), p. 391.

(6) Since correctional facilities are characteristically noncompetive and remote, and have a traditional monopoly on the channels of communication, information is easily kept from the public. As a result, onsite observation becomes an invaluable tool in the research effort, particularly in such areas as prisoner discipline, segregation and "adjustment" practices. For a particularly enlightening study on the issue, see Grosser, George H., "External Setting and Internal Relations of the Prison," in Theoretical Studies in Social Organization of the Prison, Social Science Research Council, Pamphlet 15, March, 1960.

(7) Selltiz, Claire, Marie Johoda, Morton Deutsch and Stuart W. Cook, Research Methods in Social Relations (New York: Holt, Rinehart and Winston, 1966), p. 242.

(8) Williams, J. Allen, Jr., "Interviewer-Respondent Interaction: A Study of Bias in the Information Interview," Sociometry, 27, 1964, pp. 338-352.

(9) Although limited in number, a series of excellent sometimes cross-cultural studies eliciting the viewpoint of the offender in a scientific manner are available to the researcher who seeks them, for example, Waldmann, Peter, Zielkonflite in Einer Strafanstalt (Stuttgert: Ferdinand Enke Verlag 1968.), pp. 107-148.

(10) Task Force Report: Corrections, The President's Commission on Law Enforcement and Administration of Justice (U.S. Government Printing Office: Washington, D.C., 1967), p. 7.

THE LARGE SCALE PLANNING MODULE/UNIT THEORY DESIGN FOR HOSPITALS

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The complexities of today's hospital environment are unparalleled in history. The hospital architect, who could once rely on common sense and experience to see him through, must now utilize a wide variety of highly sophisticated techniques. Recognizing the complexity of the role the architect must play, it is evident that the doctor, the nurse and the administrator share with the architect this need for more than common sense judgment to see them through .....and to utilize the wide variety of sophisticated techniques available to them.

> Until today, the architect has been totally absorbed by the urgency of the design problem itself. He has been inclined to see the rate at which building costs have increased as part of a natural economic process beyond his control. He is now denied the luxury of that view by the disturbing frequency with which his projects are being returned to him for redesign, or simply cancelled for reasons of cost. These failures are causing economic hardship to him and political and social upheaval to the community. (1)

Two concerned Federal officials, HEW Secretary Robert H. Finch, and Dr. Robert O. Egeberg, suggested that the delivery of health care would be the major social and political issue of the decade before us. In 1969, they said:

> This nation is faced with a breakdown in the delivery of health care unless immediate concerted action is taken by government and the private sector. (2)

The architects' concern can be directly related to the decision, design, and delivery of physical facilities in order to effectively raise the level of performance within reasonable costs, for both the government and private sector client to offset this breakdown and satisfy the new needs.

The emerging imperative is architecture which directly combats this costly economic process.. ...and the development of a concerted action that will produce fundamental changes in the nature of the system. But, in order to accomplish this very difficult balancing act, the design, the construction, and the health professions will have to reform their ancient ways.

> Historically, the technical aspects of the planning process were relatively simple, permitting the designer to concentrate on problems of physical form. As a result, the architect functioned largely as an artist. Today, however, the architect is expected to coordinate a growing complex of technical specialities in addition to his traditional concern with visual and spatial effects. This composite design practice contrasts with the traditional approach and has forced a total reexamination of the planning process.

Among the many external factors that have hastened this conscious attempt at reform are:

1. the increased complexity of hospital functions and the increased number of disciplines being housed;

2. an increased complexity of building technology;

3. an increased rate of technological change, causing buildings to become obsolete before completion;

4. an increased use of Federal and other public monies which require complex justification with the attendant extension of project duration.

Also fostering a reform of the process are harassment by outdated code requirements that add to construction costs; confusing, chaotic and restrictive labor practices; and an outmoded construction contract format. Finally there is the influence of a traditionally static relationship between program and design - a relationship that results in the physical design of individual, completed building packages. Such a concept precludes the possibility for expansion, change, growth, and adaptation.

Functional needs and economic problems will

> continue to exist. However, the continuing need to control costs, house essential functions, and express the resulting environment in a cohesive fashion can be resolved only through a significant architectural solution. (3)

In looking for a viable means to answer the questions of cost, change and growth in this total need for adaptability in architecture, architects concentrated on the above obvious and external issues that exacerbate the problems. The thrust was then, to respond to these problems by investigating in detail the methods, advantages and the route to any potential solution; especially, a general solution.

The Last Decade: Search for a Solution

The premise of my paper then, relates to a history of change that evolved during the past decade. The reasons for this change revolve around the economics of construction and the users' buildings' inability to adapt to changing functions and criteria, in design terms. Therefore, there is little question that the greatest change by architects and engineers in the design of medical and health facilities during the 70's will result from the use of the large scale planning module.

It is important that the technique and use of this specialized knowledge be well documented, and therefore the intent is to emphasize our experience in this area, to explain the methodological issues involved, and to discuss specific advantages and disadvantages that we have encountered in the course of the design process. This will be presented by text and by graphic illustrations. I hope to demonstrate an entirely new concept for meeting the major challenges in the development of tomorrow's hospitals.

We have taken the lead in developing and applying this powerful planning technology, and call our efforts Unit Theory Design. This concept is currently growing at a rapid rate, and is also developing important interfaces with new approaches to the management of health facility projects. For instance, overlapped scheduling provides important savings in project duration and cost, providing the design method allows effective management to proceed. We learn from each new effort and our hospital clients also learn how to lessen the constraints to an improved physical plant. The objective is a vastly improved, perhaps revolutionary form for the modern hospital.

Changing Needs vs Rigid Structure: How Can They Be Resolved

To understand the concept of UTD, a building should be thought of as a large environmental container for people, the equipment they use, and their transactions, interactions, and processes. A fire safe structure has an almost unlimited life, yet life processes and health techniques change continuously. How can the rigidity of the structure and the flexibility of life processes be resolved? The first question that Unit Theory Design seeks to answer is "What units of space will contain varying groups of persons as they perform changing functions over extended periods of time"? In answer to this, a series of equalized planning units can be determined which relate environmental systems, fire safety and traffic to a surprising number of functional program elements. These units are relatively large in floor area. They form the basis of a geometric system which can contain complex program elements and still provide ducts, pipes, fixtures, and columns in a coordinated and flexible manner.

Once the appropriate units are determined, we can refine repeated elements. This elemental principle of modern technology is seldom applied to hospital design. The result is increased predictability of the performance potential of the structure, more accurate cost prediction and increased freedom in both design and operation. As currently applied, the unit process generates these general steps:

1. Establishing categories of use for space.
2. Defining levels of environmental performance of space in response to categories of use.
3. Determining physical design criteria to produce appropriate levels of performance.
4. Estimating probabilities and time frames for future alternative uses.
5. Optimizing the use-performance-change factors against predicted costs.
6. Developing a plan unit applicable to the program.
7. Specifying the mix of units most appropriate to the specific problem. (4)

During our investigation, it was found that the current trends in planning and design for flexibility in health facilities, in most instances, emphasized two physical features:

> Long span construction: column-free floor areas to allow varied plan combinations, and

Interstitial design: space between floors to allow walk-in access for mechanical and electrical service modification and repair.

One cannot exist without the presence of the other.....for each characterizes a member of a system (Figure 1). With a minimal expertise in structural engineering, it is obvious that the depth of a member supporting a structure is a function of the span. This is readily illustrated by industrial buildings with their long span, high bay design and the overwhelming openness of airplane hangars. But, what do we do with this space that exists above an imaginary ceiling datum?....and how do we justify it in more complex building type such as a hospital. The questions have been asked by many, but answered to total satisfaction by very few.

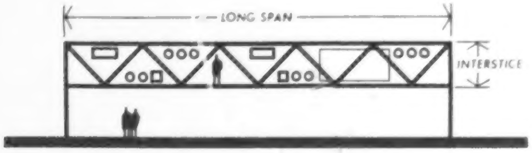

Figure 1.

What Do You Need
How Much Can You Spend?
When we discovered that some had made the attempt, and had not fully answered the question it confirmed our suspicions....that if one could do all that designers said could be done, ...it could only be done with a bottomless barrel of money.

It should be made clear that Unit Theory Design is very definitely a simplistic planning of units within a systems oriented procedure. It has no direct bearing or relationship to what is referred to as interstitial space. Rather, it makes use of interstitial space as it does many other elements of space as it directly relates to a client's need and a client's ability to pay the cost depending on a minimal or maximal amount of flexibility.

The word flexibility is much abused. It is a term that every architect has maximized and capitalized on in the area of promotion, solicitation and sales. It has become a "meaningless" kind of word, in that many architects have not delivered true flexibility. Because of this, the word is becoming obscene amongst architects.

The truth is always difficult to accept,.... and the reaction to the word flexibility, is related to your definition and understanding of it. If one honestly accepts its Webster definition, then it is:

1. Pliable, not rigid;
2. Ready to yield to influence;
3. Capable of being adapted, modified or molded;
4. Responsive, or readily adjustable to, changing conditions.

flexibility....

Now, with these definitions in mind, you begin to relate to amount and degree, and it becomes evident to the architect that the degree is first affected by a physical space or mass, and when one relates to space and mass, one naturally thinks of structure. When we think of structure we begin to apply the fundamental constraints of engineering that have a direct bearing on cost. This obviously tells us that simple post and lintel, average column-to-column span construction is less expensive than long span construction and that a space structure is even more. From this we derive terminology, which we then refer to as column structure, clear span structure, and free space structure. It is obvious then, when one relates to the other, the amount of flexibility depends on the spacing of structural and/or column obstruction. Simply stated, with lesser columns within a given space, all disciplines are more able to adapt to a new situation or change. The diagrams presented in this text clearly show these principles (Figure 2).

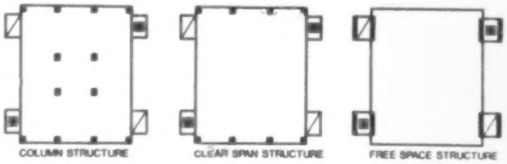

Figure 2.

The time has come for some forthright statements on what may reasonably be expected from the interstice. All kinds of magical results seem to be expected from what is nothing more than an enlarged structural depth. In the course of schematic development on numerous projects, the Mechanical discipline has been asked if an interstice would work. The answer has been that it will, subject to many qualifications concerning truss (structural depth) height, spacing, whether the building has a floor slab and what mechanical paraphernalia is expected to be accommodated therein.

Webster's Dictionary defines an interstice as a "space that intervenes between things". Most problems with mechanical systems are due to stuffing too many ducts and pipes into inadequate ceiling spaces, shafts and equipment areas. If all we get from interstices is a bigger "space", there will be some alleviation of mechanical space problems but no improvement in mechanical system performance, building efficiency or flexibility. In fact, unless something vastly better than we have seen to date is produced we can easily find ourselves committed to a structure which is completely unworkable.

Three basic questions on intent must then be answered:

1. Is all mechanical and electrical equipment intended to be housed in the Interstice with no conventional Mechanical Equipment Rooms located on true floor slabs?

2. Is the Interstice a heads-up, walk-through space accommodating services, or is it a limited-access, crawl space in which distribution (not generation) takes place?

3. How much genuine flexibility is expected of the Interstice?

If Question '1' is to be answered "Yes", then greater height and a floor slab are required, together with a vast reduction in diagonal (truss obstruction) bracing.

If Question '2' calls for distribution of services only, then unit theory design requires that each unit have its required services fed in from an external source...i.e., equipment rooms, shafts, etc.

If Question '3' calls for total flexibility, then there must be space, structural strength and accessibility to move large equipment anywhere in the interstice, or at least anywhere in a portion of each interstitial unit.

The ideal of being able to perform remodeling "behind the scenes" requires an even floor surface over which a tradesman can wheel his service cart with tools and parts. At the other end of the scale, trusses (structure) with catwalks and sprayed-on fireproofing through which only a trapeze artist could navigate are an abomination to be avoided at all costs.

An interstice calls for very close organization of all functions being performed within it. This means knowing all requirements at an early stage of development. Lack of this knowledge is a complete antithesis to an accelerated and overlapping design construct process.

Some Early Examples of the Use of Interstices

Greenwich Hospital in London, England, pointed up items worth mentioning for those planning to utilize interstitial mechanical spaces in construction.

1. The depth of major structural members is such that workmen must crouch very low to get under them in going from one section to another.

2. The layout of mechanical equipment must be done with considerable care to facilitate movement and maintenance.

3. Supervision of contractors' work is necessary to prevent their taking advantage of larger spaces and doing untidy work within the area.

4. Maintenance men are demanding more pay for the time they must work within the interstitial space.

5. Careful scheduling must occur with trades to avoid awkward situations among workmen in the "wet and dry" trades while initially installing and later testing.

6. Tools have been dropped onto, and through, the ceilings of rooms below, a potential hazard to healthy and sick alike. (5)

In addition to Greenwich Hospital, there are other similar examples. In the United States, there is the San Diego Veterans Administration Hospital that is of long span construction and interstitial design. Our research effort indicates that many of the problems outlined were also inherent in that project. But, one of the more significant points, is that the interstice does house equipment rooms in which large fans, coils, motors, etc. are located, but it's difficult to see how large pieces can be moved into these rooms if and when replacements are necessary. It is apparent that this equipment was placed before walls were enclosed, and it may be necessary to move walls and ceilings to make future replacements. A general impression of confusion is apparent, when one moves through the interstice...... pipes, ducts, etc. are not organized. The sizes of lines are dramatically large, which of course makes installation difficult....and the torturous alignment of many flexible ducts in a large space is surprising. This points out that there should be a systematic and organized planning effort. In this project it appears that the contractor proceeded in his usual manner with the first sub-contractor taking the space he chose and others working around him. This can be an occupational hazard.....when there is more room available, people have fewer decisions to make and naturally go their merry way.

McMasters Health Sciences Centre in Hamilton, Canada, also combines long span construction and interstitial design, and the comparison in many ways is similar. One of the basic differences however, is that there are penthouses on top of the modular units that house all of the equipment and the interstitial space at 7ft. 6 in. is merely used for mechanical distribution. The truss design is such that it can accept a lay-in metal catwalk over 75% of the area for maintenance, access and modification to the systems.

Children's Hospital in Washington is presently under construction, using an accelerated design/construct process. A study of its interstice indicates, that it too, is of minimal dimension. It can only be used for distribution, equipment is located elsewhere.

Recently, there has been a study on the "New Generation of Military Hospitals" by the Department of Defense. The two contractors involved, agreed on large modular construction, and on use of an interstice. However, the use of the interstice is more discriminating than in the aforementioned projects. The premise was that they simply organize the basic elements of a hospital into three areas. A combined diagnostic and therapeutic situation at the lowest levels and inpatient function at the upper levels, with the service level energizing the entire system sandwiched between. This throw-back concept, tower (patient) and slab (Rx/Dx) with services between, is a familiar pattern, and an outgrowth of Public Health Service efforts immediately following World War II.

Forerunners to interstitial design, such as the Semiconductor Building of Texas Instruments, in Dallas, incorporates an interstice, but we note the use of what is referred to by mechanical engineers as a "Jesus" room. This room accommodates all the large equipment that cannot fit reasonably well within the interstice. Again, the interstice is used for distribution. Generation takes place in the "Jesus" room, with custom packaged smaller recovery equipment within zoned areas in the interstice.

Our experience with the large scale planning module has been gained on four projects over the past two and a half years. To outline experience gained with each project in the course of these two and a half years would perhaps extend the length of this paper by this length for each project.

Four Recent Projects
With Varied Approaches

What I would like to do then, is to chronologically outline constraints and situations encountered in the course of developing these projects in a minimal but definitive manner, without concentrating on any single effort.

A teaching hospital for Michigan State University was SH&G's first endeavor and the genesis of our Unit Theory Design and the use of a large scale palnning module. It is a teaching hospital heavily oriented toward therapeutic and diagnostic functions, and related to a significant number of ambulatory patients (Figure 3).

Figure 3.

The major constraint was one of relating existing floor to floor height of a new Life Sciences building with the floors in the new proposed hospital. This, quite naturally created a structural constraint with respect to a large span and inherent structural depth.....and decision was made at an early stage for column structure design (Figure 4).

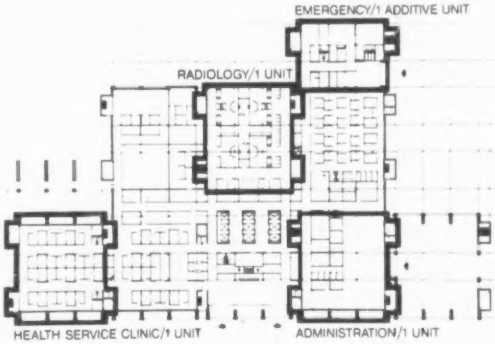

Figure 4.

The flexibility was then limited by four columns within a unit module of approximately 7,000 square feet. Smoke barriers, distance between stairs and distribution of services were all affected by this constraint. A decision was also made on equipment location. As we did not have an interstice that could accommodate equipment, we therefore made use of the "Jesus" room concept. Equipment was placed on each patient floor with distribution accommodated horizontally, and return, exhaust and additional services handled vertically (Figure 5).

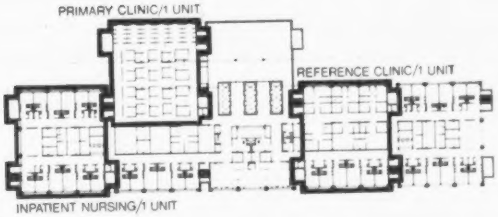

Figure 5.

This concept of locating mechanical equipment space was determined by future vertical growth, and consequently, as the isometric diagram illustrates, the mechanical equipment is located at the center of gravity and will expand vertically as the project expands horizontally. Multidirectional expansability, basic to unit theory is clearly shown....growth in phases is determined by functional priorities...eventually to connect with an expanded life sciences building. Photographs of a model showing the several stages of expansion are shown below (Figure 6).

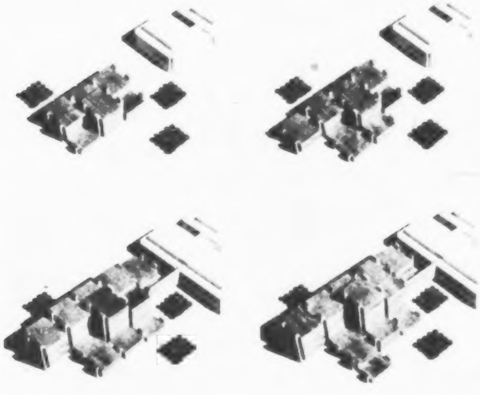

Figure 6.

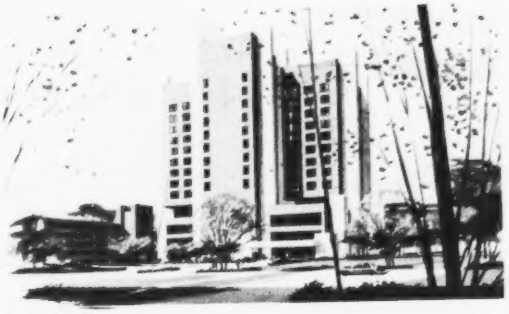

Figure 7.

Our second effort was the Grace Hospital project, a unit in the Detroit Medical Center complex. Where the MSU Hospital was considered horizontal in nature and growth, a suburban university complex with available land in all directions, Grace Hospital was an urban complex demanding a high rise vertically oriented facility with minimal prearranged horizontal growth (Figure 7).

The constraint of matching floor heights with the existing structure were limited to a basement and first floor. This allowed us to pursue the large scale planning module and our Unit Theory concept to its next stage of development, the second degree of flexibility, of clear span structure (Figure 8).

Again, we were involved in constraints of building code, and the economics of high rise construction. Using a clear span structure with its inherent structural depth, we had the advantage of an interstice. However, because of building height and volume, the location of large equipment was limited to the space between base block and tower, and to the top of the building in equipment penthouses. The cost of clear span structure was somewhat less than would have been at Michigan State University.

The single bed syndrome, a program requirement for Grace, produced a smaller module of 66 ft. x 75 ft., a unit area of approximately 5,000 sq. ft. The span depth of structure was determined by the money available to the budget. This second level of flexibility permitted a minimal walk-through situation for repair and modification, total distribution, but minimal generation by the use of custom sized equipment housed within the interstice.

With the earlier MSU project we had an open ended site. We were faced with fewer lateral restraints than in the urban site. With Grace Hospital we found that the method does adapt, and can be employed where intensive lateral constraint is encountered.

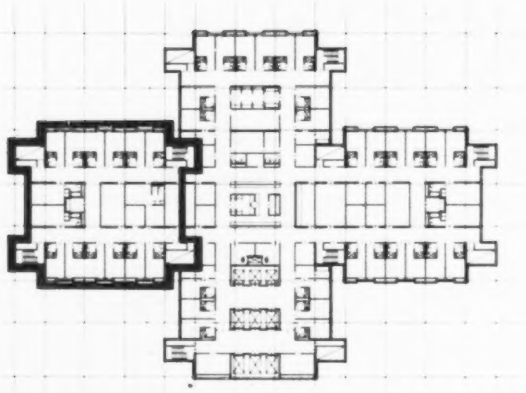

Figure 8.

The William Beaumont Hospital in suburban Detroit, was our third experience, and was perhaps a regression of Unit Theory in that, the constraint of existing floor-to-floor height was again part of the program requirements (Figure 9).

In this instance, the constraint was horrendous because of the 11 1/2 foot floor-to-floor height of the existing hospital. There was no way, other than initial consideration, for column structure Unit Theory. The HVAC problem related to floor to floor structural consideration, was solved by a combination of perimeter design and the use of service nodes for horizontal interior distribution. In addition, we had a difficult problem of design in relating an architectural mass in plan and in elevation with a strong link element, not designed by Unit Theory (Figure 10).

The first phase of this project will be breaking ground shortly under our design/construct process, the Unified Team Action Program (UTAP). It will include an ambulatory outpatient facility, emergency, and additional laboratory function. The referred to west wing addition will be designed to accommodate horizontal expansion.

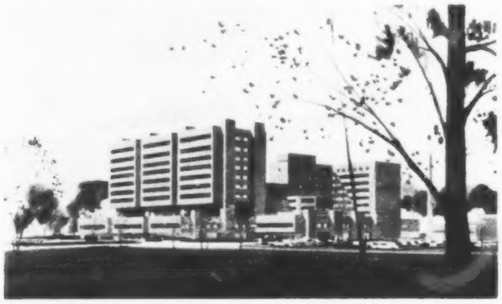

Figure 9.

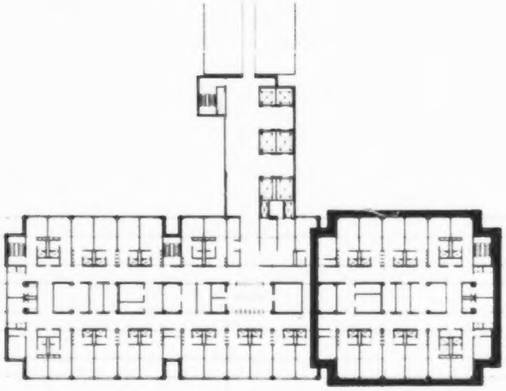

Figure 10.

Our most recent experience, the Concentrated Care Center at Georgetown University started with the premise that we would exercise all the options available to us in Unit Theory Design, but in the course of investigation and design development, we again discovered, that to exercise all options at a given time and especially in a highly sophisticated patient monitoring complex, with almost prohibitive initial equipment costs, was to again reach for that "bottomless barrel of money" (Figure 11).

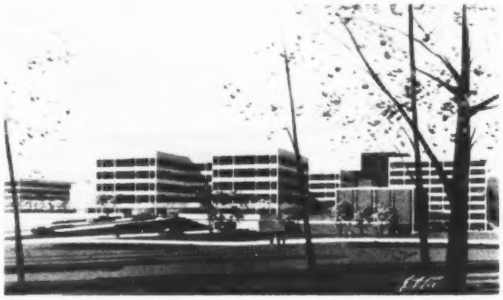

Figure 11.

Initially, we took the option of a walk-through, equipment-laden interstice between every floor (diagnostic, therapeutic and all inpatient bed floors). We overcame the problem of matching an existing floor-to-floor height of 11 1/2 feet by taking the distance of 22 to 23 feet, for an occupied floor and an interstice floor together. This allowed a connection at every level i.e. from occupied floor of the existing to occupied floor of new, and occupied floor of existing to interstice level of new. A floor-to-ceiling distance of 9' to 10' for function and a dimension that would vary from 10' to 12' for a totally viable and usable interstice. All the mechanical equipment was housed between levels by the interstice. Unfortunately, the money to exercise this total concept was not available, and other routes towards a solution were investigated.

Because of the highly sophisticated monitoring equipment needed for 160 beds in an Intensive Care situation, the flexibility was compromised to a degree that was tolerable and related to the money available. The concept is still that of Unit Theory, the module approximately 80' x 85', or 7,000 square feet, but column structure design limits flexibility (Figure 12).

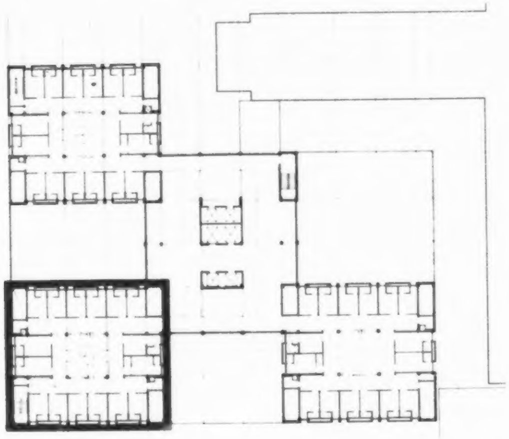

Figure 12.

Because of the environmental factors akin to Intensive Care situations (humidification, air changes, etc.), it was impossible with a column structure design to accommodate the 11 1/2 foot existing floor-to-floor dimension. This constraint was stricken from the program requirements and we now have approximately 14' floor-to-floor.

The Role of Structure in Modular Planning

We are continuing to develop our larger hospital complexes, exercising the large scale planning module, with the feeling, enthusiasm and spirit that everyone leads us to believe are possible. However, to do all that is said can be done....is possible only when the options and the economics are open ended.

With these experiences, it is apparent that the mechanical discipline plays an extremely important role in the acquiring of "flexibility" and in Unit Theory Design.

The application of Unit Theory Design to mechanical systems must consider the three variations in structural framing (previously explained) the unique advantages and disadvantages each structural system presents (Figure 2). The standard building module which UTD achieves, results in standard shaft locations throughout the structure. This allows the design engineer to use uniform plumbing and HVAC systems for similar spaces.

At the inception of a structure employing UTD, attention must be given to estimating the probabilities of alternate module use, to minimize the possibility of excessive mechanical overdesign. By studying the use/performance/change factors, the possibility of mechanical overdesign can be minimized, if not eliminated.

Once the ultimate environmental design criteria and a module mix have been established, the central apparatus and system capacities can be determined. From this point on, as long as shaft space and duct systems have been planned, no changes in these areas are required. Any change in module service is a function of system availability within the module.

The employment of an interstice that has the capability of housing equipment, optimizes the planning and layout of the mechanical systems. The interstice allows the full use of the space above the ceiling for mechanical and electrical system coordination. The mechanical designer is not limited to following corridors as he is when conventional techniques are used. Shaft locations and size are important considerations, and should be designed to allow for optimum vertical flexibility and be located to allow maximum ingress and egress.

Unit Theory Design with Column structure has the least horizontal flexibility for HVAC ductwork. The column spacing within the module is such that the duct systems suitable to that type module must be laid out to eliminate conflicts with columns and beams. The problem can be minimized if an interstice is used, since this allows use of the full ceiling plenum for mechanical systems.

Vertical and horizontal pipe flexibility within the module with this type structure is good. Large diameter HVAC pipe risers can use the shaft. However, the smaller diameter plumbing risers (waste, potable water, air, vacuum, oxygen, etc.) can be in chases at the columns. Most horizontal runs then are minimal.

Unit Theory Design with Clear Span structure provides good horizontal flexibility for HVAC ductwork. The column spacing within the module is such that the duct systems suitable to that type of module can be laid out with a minimum of interference with beams and columns. Because of the inherent depth created by span, an interstice space will eliminate most, if not all, horizontal flexibility problems. The vertical flexibility in the module is reduced with clear span structure. The availability of columns for chasing and "wet use" is less, therefore the horizontal runs are longer.

Unit Theory Design with Free Space structure has excellent horizontal flexibility for HVAC ductwork and piping. The absence of columns in the module gives the mechanical designer wide latitude in laying out the ductwork systems germane to that type of module.

With free space and interstice, planned changes in space use are executed with a minimum of interference in occupied space. Vertical flexibility is dependent upon shaft location and accessibility. The space in the ceiling plenum must be carefully stratified to provide vertical and horizontal space for piping runouts and waste mains.

Common Denominator

Our development of UTD for M.S.U., Grace, Beaumont and Georgetown, related program development (systems oriented programming process) with a developing unit theory of design. The design information was tailored to the level required by the state of design progress and not of necessity to an overly specific program. John Weeks in his discertation "Indeterminate Architecture", almost a decade ago....explained a position, totally supported by us today.

> What design rules, if any, are appropriate? It has seemed to me for some time that the need to accommodate growth and change in hospital design is certain and indeed that it has to be accepted even during design. (6)

The relationship of elements was emphasized to an uncommon degree.....and it was this combined process that determined relationships, producing extensive design analysis and obviating premature design synthesis. When synthesizing against an indeterminate program,.... the architectural mass always took on an attitude of geometric aformality....again supporting Week's theories.

> A building for an indeterminate brief cannot then adhere to a finite geometric control system. The ideal of unity through constant relationships cannot be achieved. Such a building will be geometrically aformal. (7)

The idea was to assemble units and their additives, which meet the necessary conditions, these to be translated into a system of structural and mechanical requirements thereby producing a dimensionally viable and adaptable spatial configuration (Figure 13). This diagram indicates the difference in profile configuration and in area, that is arrived at by mix.

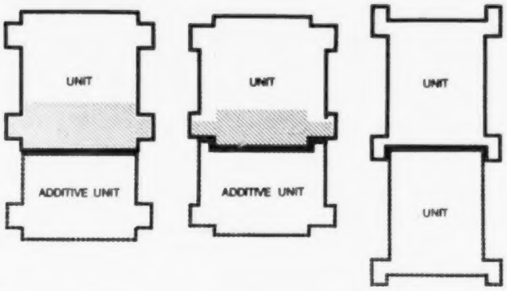

Figure 13.

As defined elements brought together the many activities and functions into a unit or combination of units, into as large a space as possible, common disciplines; to produce elements that repeat and are recognizable by virtue of their physical characteristics....in short, to find a common denominator (Figure 14).

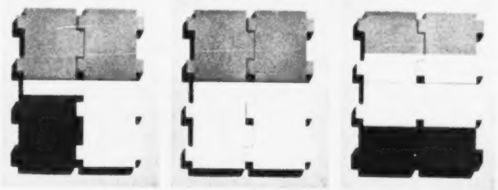

Figure 14.

With this in mind, we started with the patient room as a sub-system module,....thought in terms of conventional double corridor nursing, considered in a simplistic fashion the consequences of mechanical, electrical shafts, egress stairs, convenience stairs, columns and elevator bank within a configuration (Figure 15).

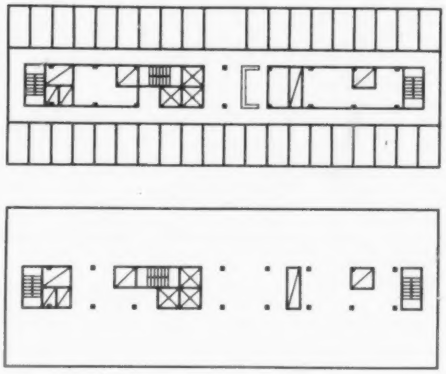

Figure 15.

We then considered advantages to be gained by locating mechanical, electrical shafts, elevator bank....and the necessary number of convenience and egress stairs required by code, at the perimeter of the form,....providing a clear space within which most any discipline, can be accommodated by virtue of free space (Figure 16).

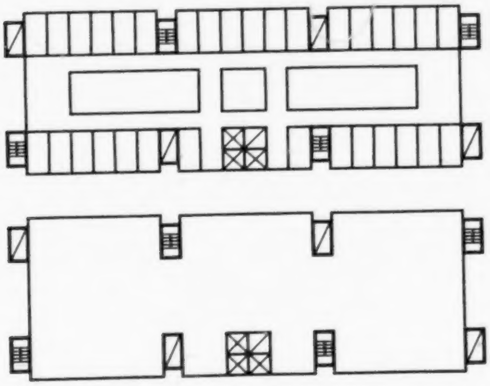

Figure 16.

The most positive consideration in the design of the unit or module....was the realistic assessment of structural cost related to actual and honest future use (flexibility). We explained in detail the structural and mechanical options of Column structure, Long Span structure and Free Space structure, combined with shaft and stair nodes. To re-cap, the stairs and shafts are part of the unit; smoke barrier, area of refuge and egress limits, in combination of mechanical/electrical with structure, and function, produce a unit module (Figure 17).

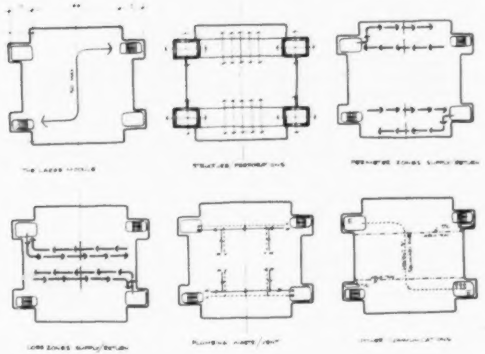

Figure 17.

The unit modules have the capability of movement and expansion, with the possibility of many variations on adjacency and function (Figure 18).

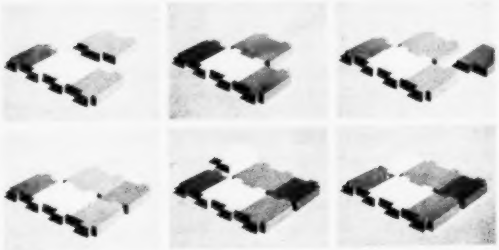

Figure 18.

Construction Method vs Design Method

Prefabrication (as a mechanism of industrialization), systems building, (opened and closed systems), capsulization and component construction are the most prevalent of current concepts. Obviously, these approaches relate to construction method, not design method. However, they do affect design in important ways, and their effect on the product must be ascertained. Our approach is intentionally oriented to the users of buildings. Regardless of the fabrication process, organization of user requirements must occur, and the environment thus created must be acceptable and preferably inspirational.

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17: INCREASING THE WORK EFFECTIVENESS OF DESIGN TEAMS

INNOVATION IN THE DESIGN AND MANAGEMENT OF PUBLIC HOUSING: A CASE STUDY OF APPLIED RESEARCH

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Office of the Assistant Secretary
for Research and Technology
Department of Housing and Urban Development

Useful case studies generally offer two related kinds of knowledge. First, they report on work which is significant in its own right by virtue of the importance of the problem analysed and/or the methodology or approach employed. Secondly, useful case studies often extract from that knowledge and the total experience of the project, insight into larger process. In presenting a case study of HUD's Innovative Modernization Project (IMP), a large HUD Research and Demonstration project aimed at improving public housing, which the author developed and managed, this paper will attempt to meet these criteria. It will discuss the purpose and scope of the project as well as report the major findings that have been generated by the project thus far. The paper will also view the project from the perspective of what it tells us about some of the problems that must be overcome in projects like these if research is going to influence the management of public programs and the expenditure of funds within these programs.

Scope and Purpose of IMP

The purposes of IMP are ambitious. According to the project's work statement, its purposes are: "to develop, test and evaluate, in two housing projects in each of three cities, new ways to modernize public housing projects so to make them more satisfying to the tenants, more economic to operate, less subject to crime, vandalism and property abuse and more conducive to helping tenants achieve self-sufficiency, self-fulfillment and upward mobility."

Originally we defined "modernizing public housing projects" to include largely physical changes as we had our eye on assisting the execution of HUD's regular Modernization Program, a program which annually provides local housing authorities with roughly 100 million dollars a year for primarily physical improvements in housing projects. As we got into the project, however, we quickly broadened our definition of modernization to include changes in the management of housing projects as well. It became clear that management practices and the physical design of projects were closely related in terms of their effect on tenants and the overall efficiency of project operation.

We were also encouraged to broaden the scope of the innovations we wanted to develop and test because of HUD's recent authorization to grant housing authorities, the local public bodies responsible for operating public housing, operating subsidies.

Given the goals of the project, we were immediately faced with the question of how best to structure the project so as to assure that the analysis would be realistic and that the findings of the project would have maximum impact on the system we wanted to see if we could improve. We knew that the work had to be developed and presented in such a way as to be of practical value to our immediate clients whom we saw as other housing authorities as well as HUD staff responsible for providing guidance and support for the construction, design and management of public housing.

We had a couple of choices. One, we could contract with R&D firms and have them survey a number of housing authorities and projects within these authorities and make recommendations on that basis. This choice would allow us at HUD to work directly with the R&D firm, and the research emphasis of this approach would assure us of a rather precise product based on a wide ranging analysis.

The other approach, the one we opted for, was to choose a small number of housing authorities to work with and to provide them with the resources to secure the services of competent R&D firms, rather than to contract with these organizations ourselves. In this way, we hoped to fuse the technical and the realistic. The authorities would provide the realistic setting and the practical experience while the R&D organizations would offer research and analytic skills. Specifically, we wanted housing authorities that would be prepared to take the lead in developing improvements to be implemented in their own authority-wide operations and who could also offer us two housing projects that could be used as demonstration sites in which innovations in the design and management of public housing could actually be tested. For the R&D organizations, we needed ones with interdisciplinary skills in management analysis, design, the social sciences, and community organization.

This decision led us to contract with the housing authorities of Cleveland, Allegheny County in Pennsylvania, and San Francisco. These authorities then entered into contracts with R&D organizations for the technical work involved in the project. On the basis of competitive procurement, a research group led by Action-Housing of Pittsburgh was selected to work with the Allegheny County Housing Authority; The Environmental Research and Development Foundation (ERDF) of Kansas City was chosen to work with the Cleveland Authority; and the Organization for Social and Technologial Innovation (OSTI) along with Building Systems Development (BSD) was chosen to work in San Francisco. OSTI later withdrew but the work has continued with the same staff under a different corporate entity: Urban and Rural Systems Associates (URSA) in joint venture with BSD.

What developed then was a two phase project. In the first phase, just now completed in two of the cities, each housing authority, working with its R&D group, was charged with the task of developing an innovative modernization plan which would set forth improvements to be tested in two housing projects as well as in related authority-wide procedures and operations. The plan, the bulk of which was to be directed at the demonstration sites, was to be based on an awareness of the general problems facing public housing and on a detailed analysis of the two projects, including their design, management operations and the characteristics of their tenant populations.

The plan itself was to describe the innovations to be tested, present the rationale for the selection of each innovation, and provide a plan for evaluating the effects of applying the recommended innovations. The kinds of innovations we were particularly interested in were those that struck at a fundamental problem in public housing, were capable of precise description and evaluation, and had some promise of being cost-effective to assure the feasibility of applying them elsewhere where special funding sources would not be available.

In Phase II, the plan developed in Phase I will be implemented with regular HUD Modernization Program funds and HUD operating subsidy funds which have been earmarked for this purpose. HUD Research and Technology funds which covered the development of the plan will be used to monitor and evaluate the results of this implementation. All told, we have allocated approximately 4 million dollars for all phases of the project.

The reason that the structure of the project has been stressed at this point is because it represents a conscious effort on our part to organize the project in such a way that the results would be sure to count. In this case, that objective meant contracting with housing authorities rather than going directly to R&D firms. We did this because we wanted a realistic setting for our research and because we believed that these authorities, although not usually the recipients of R&D funds did have new ideas and approaches to contribute, especally when coupled with expert R&D firms. This same concern for making sure that the results of the research would penetrate the formal operating system and its procedures also governed our decision to arrange for the earmarking of HUD operating subsidy and modernization program funds to execute the plan developed with HUD Research and Technology funds in Phase 1. Not only would the execution of the plan provide visible evidence instead of "just another study," but we felt that if we gave the offices and people who regularly administered these funds the responsibility for executing plans developed through the use of R&D techniques, then interest and participation would follow. In this way, we tried to assure that the findings and lessons of the project would be noticed and absorbed by those who deal with the problems of public housing on a day-by-day basis.

This model for structuring R&D projects is being emphased in subsequent HUD projects in the area of housing management. In the fall of this year, over 250 local housing authorities were invited by the Department to join with R&D firms and submit to the Department proposals for the design and implementation of new management systems for public housing.

Highlights of the Innovative Modernization Plans

By November of 1971, the time of this writing, the San Francisco and Cleveland Housing Authorities had completed their Phase I innovative modernization plans and had received HUD approval to proceed with implementation. Allegheny County's plan is currently being reviewed by HUD. What follow is a brief account of the major components of these plans and the major themes of the supporting research.

Although the plans differ because of differences in the demonstration sites, the Authorities themselves, and differences in the research groups and the perceived needs of the tenants, there are some common findings that provided the basis for a large part of the individual plans. One such finding was that there was a fairly clear relationship between the quality of management's services, e.g., maintenance, the attitudes of the tenants, housing authority policies and the physical condition of the projects. All these factors seemed to be related and to influence one another.

A limited scenario illustrating this point would probably go as follows: The housing authority delivers inadaquate maintenance services. This angers and discourages the tenants. As a result they fail to report maintenance problems that could ultimately lead to major breakdowns. They also fail to take care of the things they could take care of themselves and they occasionally engage in vandalism or fail to restrain others from doing so.

These responses contribute to the physical deterioration of the project, encourage the authority in some cases to engage in punitive policies and, because they increase the cost of maintenance, the gap is therefore made even wider between the authority's ability to deliver maintenance services and the need for them--the very factor that contributed to the tenant's negative attitudes in the first place.

The physical design of the projects and the socio-economic background of tenants as well as their capacity to help and support one another were also identified as elements in the complex series of relationships that shapes the quality of life in public housing. In the case of the buildings we are working in, all of them have severe design deficiencies. These deficiencies not only impact negatively on the physical condition of the buildings by making maintenance difficult but they also inhibit the development of a sense of community. The projects are all filled, for example, with dark, ugly and threatening places whether its the stairways between floors in the project in Allegheny County that has skip-stop elevators, or the smoke towers in the project in San Francisco, or the dimly lit, lonesome labyrinth pathways through our sprawling project in Cleveland. In each of these projects, the design makes the building and its residents vulnerable to vandalism and crime, and the absence of defined activity centers and places for spontaneous interaction and viewing tend to isolate the residents. All the projects lack behavorial cues related to space. The design of the projects and their layout fails to suggest what kind of behavior is appropriate or who should, or should not, be in a particular space. Space use is rarely defined and where it is, oddly enough, the design is often resisted. Childern do not play, for example, where they are supposed to. The few playgrounds in the projects are rarely used.

Research supporting the plans also revealed that we are dealing with a large permanent population in these projects--the kind of population that public housing was not really intended to serve when the program began during the depression. Originally, public housing was designed to house the deserving and the temporarily needful members of the working classes who had fallen on hard times. Public housing was to be a rather spartan way station until the depression subsided and these families could once again move back into the middle class. The family in mind and the family public housing orginally served was the solid American family--usually white in those days--with a Papa Bear, Mama Bear and only a couple of baby bears. What we have now, however, is an entirely different situation. The tenants of our projects are not merely bruised socially and economically. They are poor. Their incomes invaribly fall below the poverty line, and over the years public housing has been serving an increasingly poorer population. In the big cities that population has increasingly been black with more and more female headed households. It is not uncommon in big city projects for the adult-male to children ratio to run as high as 80 or a 100 to 1.

Our research also revealed a lack of a sense of community. People didn't know each other very well and their expectation for improvement in the project was generally low; and neither did they seem to help or support each other very much. They were not prone to report acts of vandalism or even the destruction of a neighbor's personal property. In brief, and at the risk of oversimplying a great deal of research, the residents seemed to lack a sense of identity and affiliation with anything in between the immediate family and the project at large. Beyond the family unit there was little they could turn to within the project. Although they identified themselves with the project, of course, this was generally too vast, too negative, and too impersonal a setting to be particularily supportive.

These findings led all the plans to include measures intended to bring a sense of community to the projects, and specifically to try to establish smaller social groupings within the projects. This involved, as we shall see below, design changes, changes in the location of some of the facilities, the introduction of new facilities, and changes in management practices and procedures governing the projects.

Another general conclusion that emerged was that there was a need for better housing authority control over the maintenance work being done and a need to establish systems that would allow responsibility and authority to come together in such a way that organizational units could be held accountable for the delivery of services to the tenants.

Each plan reflects these findings but in a somewhat different way, and each plan reflects an attempt to respond in kind to synergistic problems--to fashion a response that is as integrated and related as the problems seem to be.

What follows is a brief sketch of the major features of each plan:

San Francisco: Consistent with the goals of TMP, the plan developed by the San Francisco

Housing Authority and its research group, URSA and BSD, was directed at two major problems: the unsatisfactory living environments offered by much of public housing and operations of the authority that were uneconomic. The plan, which was prepared under the leadership of Noel Day, of URSA, held that these two problems "result from the interactions of the individual social and institutional behaviors of three groups of actors (tenants, the housing authority, and the "larger community") within the physical context that consists of the physical location of the project, the physical design of the project, and its physical condition."

To influence these crucial variables, the San Francisco plan proposed five clusters of innovations. Each cluster is aimed at a realistic point of intervention and is intended to present a concentrated attack on one or more of the factors that relate directly to the problems of authority operations and the living environment provided by the projects.

The first cluster of innovations is directed at the redesign of the Authority's maintenance system under the assumption that increased efficiency will increase tenant satisfaction and the physical condition of the projects. Major innovations in this cluster include the establishment of a central maintenance planning and operations facility for the whole Authority. This facility will provide a command center for receiving maintenance requests and for routing responses. A companion innovation will be the introduction of a quality control system which will involve follow-up calls to the tenants to see that the work was done as well as having residents periodically fill out a checklist in which they rate the quality of the maintenance they have been receiving. Together, these innovations should contribute to tenant satisfaction by providing more prompt, reliable and personalized service. They should also give the authority better data and feedback on its maintenance needs and costs, and provide it with better control over maintenance staff.

Another innovation in this first cluster is the introduction of a saturated maintenance program for the two demonstration housing projects. This involves putting these projects into top physical condition by taking care of all deferred maintenance. The cost-effectiveness of this approach would then be analysed to see if the results of increased tenant satisfaction, coupled with the longer run savings of doing preventive maintenance,would outweigh over a period of time the high initial cost of this approach. As it stands now, it should be noted, the San Francisco Authority, like most housing authorities operates largely on a complaint maintenance system. Due to budgetary constraints they are rarely able to do much preventive maintenance. For the most part, it is all they can do to respond to tenant complaints.

The second cluster in the San Francisco plan involves management redesign. Here again the objective is to increase the Authority's performance and efficiency of operations. Innovations in the cluster include the introduction of new cost and accounting analyses procedures, providing staff with attitude and skill training as well as incentive programs. It also includes the adoption of procedures that would allow the Authority to identify vacancies quickly before the empty unit is vandalized.

The third cluster consists of communications and information systems for tenants and Authority staff. Innovations include the preparation of tenant orientation materials and the issuance of bulletins and newsletters. These measures are intended to help build a sense of community by announcing local news and tenant events. They are also to provide tenants with accurate information about current Authority operations and give them some understanding of the basis for these operations--where the money comes from, where it goes and why. This is to give the tenants a better appreciation of the constraints the Authority is under as well as an awareness of some of the effects tenant behavior has on the ability of the Authority to deliver services.

The last two clusters of the San Francisco plan involve changes and improvements in the design and physical condition of the two demonstration sites, Hunters View and Yerba Buena Plaza (East). Although the approach used by the research group to these two projects was similar, the projects themselves are quite different in design. Yerba Buena Plaza consists of two high-rise buildings of eleven occupancy stories each; one five story building, and eight three story walkup buildings comprising a total of 276 units. The two high-rises frame two sides of a courtyard. The lower-rise structures cover the other two sides of the courtyard and extend beyond the high-rises. There is thus a large interior courtyard and two U-shaped configurations on the other sides of the high-rises.

The innovations planned for Yerba Buena, as stated in the Housing Authority's Phase I Summary Report authored by Noel Day of URSA, are as follows:

> 1. Improved access control. Three approaches to controlling access will be used. First, elements of the site will be redesigned: a number of existing entrances and exits to the high-rise towers will be closed or controlled by mechanical gates; an entry-lobby-guardhouse will be constructed--

both at major access points.

Second, new hardware will be installed. In addition to the gates noted above, police-type bar locks will be provided for the individual dwelling units as will wideangle "peepholes" for the dwelling unit doors.

2. Surveillance system: will consist of closed circuit T.V. and modular alarm surveillance of the emergency exits, the exit from the multi-purpose center to the street, and the entrance and exits to the six-story building. The monitoring console and an emergency coded-message transmitter will be located in the entry-lobby-guardhouse area. In addition, T.V. cameras will be concealed in two of the four elevators although all four elevators will be posted with notices that occupants are under T.V. surveillance.

3. Smoketower redesign: one of the two smoketowers (fire stairs) in each of the high-rise buildings will be redesigned by opening it up to visual surveillance from interior hallways and from the outside courtyard. Vandal-proof glass will be installed and with vandal-proof fixtures and higher lighting levels.

4. High activity corridor: to further capitalize on opportunities for higher levels of contact between tenants created by limiting access and channeling pedestrain flow through a limited number of entrances and exits, the design of the interior courtyard will be modified, a protective "trellis" will be constructed, and amenities will be added to encourage entensive and prolonged use by different age groups of tenants. Activity areas will be provided along an aesthetically pleasing axis between the entry lobby and the multi-purpose center at the other end of the courtyard. Along this axis or corridor, there will be activity areas for tots, children, teenagers and adults.

5. "Buddy" system surveillance: in an attempt to compensate for design features that limit or discourage surveillance and for distrust and alienation between tenants, a buddy system will be organized on a limited scale. Half of the three-story buildings, four selected floors of the six-story building will be involved with each offering opportunities for a different way of grouping dwelling units for the system. "Buddy" system groupings of dwelling units will be distinguished by matching brightly-colored doors.

6. Increase level of services and amenities. Construction of a multi-purpose center will provide the main vehicle for accomplishing this aim. The Center will house a laundromat, a multi-purpose room, kitchen, toilets, and circulation space, etc. The Center will be operated six days per week for 14 hours per day. Staff, drawn from the tenant population, will be responsible for operations and the tenant organization will be the recipient of any profits derived from the operation of the Center--particularly the laundromat.

In addition to the amenities noted above in connection with the description of the high activity corridor, several other features will be introduced. "Super-graphics" (large contemporary designs incorporating numbers or letters) will be applied on the landing walls in the redesigned smoketowers; community artists will be commissioned to create murals in the elevator lobbies of the high rise buildings and the front wall of the entry-lobby-guardhouse building; combination bulletin-graffitti walls will be located next to the elevators on each floor of the high-rise building and on one wall of each of the elevators--these surfaces will be cleaned or refinished periodically.

7. Individualization of dwelling units. Four methods will be utilized to encourage individualization of dwelling units by tenants. First, SFHA will supply paint and materials and the expert guidance of a union painter to tenants who want to paint their units. Second, interior design counseling will be provided to tenants by volunteers drawn from local schools of design. Third, workshop opportunities will be provided for tenants to enable them to do simple repairs and homemaking projects. Fourth, house maintenance equipment--administered by the tenant organization--will be available for low-cost rental by tenants.

In contrast to Yerba Buena Plaza, the other project selected in San Francisco, Hunters View, is a cluster of 56 low structures holding 350 units. The buildings are two and three stories of wood frame construction. They sprawl, barracks like, on one of the hills of the Hunters

Point area in southeastern San Francisco.

The innovations scheduled for Hunters View are similiar in concept to those scheduled for Yerba Buena. Access control will be improved, some new hardware will be tested, and space will be differentiated into private, common and public.

Cleveland: The plan submitted by the Cleveland Housing Authority and its research group, the Environmental Research and Development Foundation (ERDF) of Kansas City, is almost exclusively directed at testing innovations in the demonstration site.

The site chosen in Cleveland is a portion of the Carver-Owthwaite project. Shaped like an arrowhead, the site consists of thirty-nine buildings, housing over 1700 residents, spread over 20 acres. The buildings are of two types, row and walkup apartments. They are connected by walkways that thread their way through the project. Like most public housing it is a generally dependent environment with a large percentage of women and children. The mean income of the families is considerably below the poverty line. The average length of residence is 8 years 3 months, somewhat above the national average.

The dominant feature of this site is its vastness. There are no clues to appropriate behavior related to space. The environment is generally "permissive" and vulnerable. It is unclear how space should be used or who should use it. Walkways wander through drab rows of buildings that all seem to look the same.

The essence of the Cleveland plan is its proposal to break up this huge project into seven neighborhoods that could provide some sort of social support and some sense of positive identity for the residents. The basis for the demarcation of neighborhoods was not artifical. It was determined by extensive analyses of the patterns of interaction among the residents and the physical design of the project. Behavorial setting analysis employed by Robert Bechtel, a social scientist, coupled with the insight of Myles Stevens, an architect also with ERDF, uncovered the seven distinct socio-physical areas which provided the basis for the neighborhoods.

The Cleveland plan calls for reinforcing these informal socio-physical areas. Each area will have building superintendents assigned it, a move that will not only give the neighborhood greater efficacy but will also allow us to test the decentralization of the delivery of management services. In addition, each neighborhood will be color coded and will receive a special demonstration. As in the case of the building superintentents, these special demonstrations will help give the neighborhood definition as well as allow for the evaluation and comparision of innovative approaches.

The special demonstrations scheduled for each of the neighborhoods includes testing materials that might be cost-effective in the long-run because of low maintenance. Vandal-proof materials and devices, such as durable glass, metal doors and special mail boxes are included in these demonstrations. Waste compactors to replace building incinerators have also been proposed.

Other special demonstrations include a saturation maintenance program for one neighborhood such as we are trying in San Francisco, and a lighting demonstration which would increase illumination in areas research has identified as being particularily dangerous. Another example of a planned demonstration is one that involves moving interior stairs outside of the building. This not only allows the apartments to be made larger but it makes the stairs visible, thus providing the resident with greater protection and security than now exists since these interior stairs have frequently been the scene of criminal activity and violence against the residents.

Allegheny County: The Allegheny plan, which has just been submitted to HUD for approval and has therefore not been available for extensive review, proposes innovations in two broad areas: Management Systems and Project Services. Innovations in the management systems catagory include the implementation of an improved planning, budgeting and control system intended to improve the Authority's capacity to set long and short range goals and to provide the necessary information to allow the Authority to monitor and evaluate progress toward these goals.

To further make "accountability" feasible by concentrating authority and responsibility in visible and accessible organizational units, the plan also proposes that many of the operations governing the two demonstration sites, Talbot Towers and McKees Rocks Terrace, be decentralized. It is proposed that the project manager supervise all on-site personnel, including maintenance and security staff who now report to a central authority. Again in contrast to present practice, the manager would make major decisions concerning purchasing, maintenance and social services. He would also be responsible for preparing, in cooperation with the tenant council, a detailed annual budget which would set forth goals for the project and approaches to meeting these goals. Modifications in the budget would also be made with the cooperation of the tenant council whose expertise and importance would be upgraded as part of the plan.

Innovations in the Project Services catagory of the Allegheny plan also focus on the demonstration sites. Similiar in concept to those in the other plans it is proposed that space be better and more precisely defined, access to the projects be controlled and facilities designed and positioned so as to give the projects an inward focus, encouraging contact and interchange among the residents.

Problems of Applied Research

In addition to the value of the project itself and what we are learning from it, IMP points up a number of problems that probably must be faced in almost any applied research project on public programs.

First, there is the fact that the objectives of many applied research projects like IMP are extremely demanding. They present the research group with the immediate problem of converting general policy and program goals into researchable issues, capable of precise definition and measurement. Yet this is the way the relevant problems--the exciting ones--come to us. Not as rigorously framed hypotheses, but as problems--at least in the case of public housing--of unhappy people, high operating costs, too much crime and vandalism, and other problems which stem oftentimes from multi-problem families being collected together in large projects--a situation that seems to bring out the worst in everybody. For applied research projects to be successful, therefore, researchers must have the capability to solve problems which are initially phrased in terms not unlike the project reviewed here, and they must provide answers as research scientists. They should not simply duplicate the program manager's approach. While the research scientist looks at the same things the program manager looks at, he looks at them in a different way, using a different level of analysis. It is in this manner that the researcher provides new dimensions of understanding.

IMP also points up the need for interdisciplinary approaches--something we have heard a great deal about in recent years but which in practice often turns out to be multidisciplinary or simply nondisciplinary. In the case of IMP, we needed R&D groups who not only had some background in housing, but who also had skills in the social sciences, the management sciences, architecture, planning and community organization. We found such groups after a thorough and rigorous selection process and the plans developed by these groups speak for themselves about the ability of these teams to harness a variety of disciplines. It is still clear, however, that the research community needs to do a great deal more work on the framing and design of interdisciplinary approaches. Perhaps we should look toward the development of a methodology of methodologies, one that would allow us to integrate approaches rather than to collect them.

Still another problem suggested by the objectives of this project is that they may be false or unrealistic, or based upon incorrect assumptions. This is always a concern in applied research missions. There is always the fear that you may be studying the wrong problem--or be so bound by the assumptions supporting the operating program you are examining that the critical factors or the critical set of relationships is overlooked. Indeed, when you try to analyze some of the problems confronting public housing by studying the management of the projects themselves, or by analyzing how available resources are allocated within these projects, there is the danger that you are like a mechanic tinkering with the carburetor on an engine with a cracked block. The problem may not be one of housing management, or of how to spend HUD modernization or operating funds more effectively. The problem may be more fundamental. It may, for example, be that there simply isn't enough money, or compression, in the system to drive it where it should go.

These kinds of questions concerned us in our decision to fund IMP, and we recognized that many of the problems in public housing may stem from the subsidy system or simply occur as a consequence of housing families with difficult problems in high densities. However, it was still necessary, in our view, that we test and evaluate new approaches to allocating the present level of resources within the constraints of existing programs, especially when the funds are as substantial as those released under HUD's Modernization Program and operating subsidies.

Another problem that needs to be identified--one that is clearly part of any action type research--is the difficulty of gathering data on the behavior, feelings and attitudes of low income families, or even interviewing them or observing their behavior in a systematic fashion. We must realize that low income families have no particular interest in research. In their view they frequently feel they know what should be done. And what is required is not research, but action. Their lives, moreover, are full of people from public agencies asking questions, or interviewing them about one thing or another, and they regard many of these questions as stupid, ill-informed or humiliating. Because of these orientations, research scientists must make a special effort to secure cooperation. In many cases, this might mean talking at length to the leadership of the group or neighborhood under analysis to enlist their support for the project. In addition, it might be necessary to pay the respondents who are interviewed or the panels that are used. In all cases, however, it means that the researcher must have the capability to relate in an interpersonal way to the people whose behavior, values and attitudes he is trying to understand in a systematic way. In the case of IMP, we committed ourselves at the outset to tenant involvement. We did this because we felt the tenants had important things to say about ways to improve the living environment of the projects--which certainly proved to be the case--and because we knew that no innovation would succeed without their cooperation. HUD policy, moverover, requires that tenants be involved in the development of Housing Authority modernization programs and we wanted to develop effective ways of achieving this.

There are however, some inevitable costs and difficulties encountered in involving tenants in applied R&D projects. First, their involvement may skew the findings or tilt the whole project so much that the procedures used may not be replicable. From a strict research point of view, the project may become contaminated. It may become difficult, for example, to assess how much the results were due to key personalities or how much they were due to the process that was actually followed. A second possible consequence of this kind of involvement in research is that the research team, unless carefully managed, may fall under the sway of its community organizing component and become so identified with the very real and often touching needs of the tenants that the research orientation is lost. When that happens, the potential for the project to maintain sufficient rigor so as to generate findings which are convincing enough from a research standpoint to be applicable elsewhere is lost, and the R&D project simply becomes another urban project with a narrow, if understandably heartfelt, perspective.

We had to deal with this problem in IMP and it is clear from the plans that trade-offs had to be made. Yet the project has maintained its integrity as a research project. Although not all the innovations will be clearly replicable elsewhere, they will increase our knowledge about how to improve public housing and their installation will certainly improve the living environment of the demonstration projects.

Another problem facing applied research is the need for the research group to gain sufficient practical knowledge about the program under analysis and to understand the perspectives of the managers running the program. In IMP, we were fortunate to have R&D groups with experience in housing. Yet they still wisely spent a great deal of time meeting and talking with housing authority staff and getting their insight and judgments. This was necessary in order for the R&D firms to make their unique, research oriented contribution to the development of the plans.

These then are some of the broader issues about applied research suggested by IMP. It seems clear that for applied research to work it is necessary that the research community continue to try and adapt what it knows about human behavior to the urban field; that researchers take the time to learn the problems as the urban program manager sees them and to train themselves to work with the poor and the deprived--the consumers of our urban programs. If these things are done and efforts are continued to develop the methodological skills that would allow us to break down urban problems into manageable analytic and researchable issues, then prospects should be bright for applied research making an important contribution. IMP is one effort and we are encouraged when we look at work to date that we have demonstrated the value of this kind of research.

ARCHITECTURAL VALUES AS A MEASURE OF DESIGN DECISION MAKING
AN EMPIRICAL STUDY USING THE CONCEPTUAL FRAMEWORK OF POLITICAL SCIENCE

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The Definition of Ideology

This paper is an attempt to distinguish groups of architects working in different areas of the profession in terms of their distinctive ideologies or belief systems. A belief system is defined as an interelated set of values of different levels of specificity. The strength of the relationship between the parts tells us how structured or cohesive the system is. The combination of various levels of generality means that we can include both an abstract endorsement of values along with their specific applications. The idea that values can be concretised by their verbal expressions has been accepted in measurement of, for instance, political ideologies and a logical extension for our purposes is to consider formal decisions by an architect as concrete physical expressions of his more abstract values. This allows us to build up a picture of the architect's style of design which is defined as both symbolic and physical.

Another very important advantage of describing ideological systems as sets of interelated values is that we can talk about the thing measured in a number of different ways, e.g. we can discuss the general cultural values, the particular group norms and the individual beliefs which all structure the design decision making process. The method is in effect, a useful analytical tool in that it allows us to say about an ideology that it is for example, conservative in social outlook, elitist in its group values and psychologically rigid in structure; implications can be followed from one sphere into another in a meaningful and intelligible way.

To clarify the kind of ideological structures that the empirical study isolates I will consider these first of all in general political terms. This should make it evident that in the same way some political ideologies have direct architectural implications so some architectural ideologies have direct political implications. What I hope to show is that implicit in architectural values there are political statements and I stress this because a lot of research in architecture, in particular, that in design decision making, is invalidated by ignoring this fact.

Consider Mies van der Rohe's relationship with the Wiemar Republic and the massive structures he designed. Consider Hitler's political aspirations and the type of buildings he had designed (or designed himself) to reflect these. Consider the different personal and cultural styles reflected in the palaces designed by Louis Fourteenth and Fifteenth. Consider the relationship between socialist theories of class and the styles of mass housing these gave rise to, in particular high rise flats. Where does the political ideology end and the architectural one begin in these examples ?

Rationalism and Pragmatism

Most of the above examples reflect what I intend to define as rationalistic tendencies, that is, they are utopian or visionary and emphasise the need for complete change and destruction of traditional ways of life. This rationalism contrasts with what I call pragmatism which is based solidly on experience of a culture and a desire to reflect the subtleties of a tradition. These distinctions are not directly related to ordinary political labels like Republican, socialist, liberal, Democrat, etc. the distinction being made here is at a high level of abstraction and refers more than anything to the difference between personal and cultural philosophies which are self-conscious and explicit and those which are unselfconscious and implicit (compare the American constitution which is a written document of "the rights of man", with the British constitution which is a set of informal customs and rules handed down over generations).

A good architectural example which explains the distinction is a "non-plan" planning proposal made by British architect Cedric Price against a regional control proposal. The details are not important but the point is, as Michael Oakeshott says "a plan to resist all planning may be better than its opposite but it belongs to the same style of politics",both are "politics of the book". (1)

Christopher Alexander's early design method ideas, the notion that buildings determine behaviour patterns and neighbourhood units in planning can be described as rationalistic whereas Venturi's theories of design, Amos Rappoport's stress on complexity and ambiguity in buildings and office training for architectural students are essentially pragmatic. The difference is one which must be intuitively recognised as well as verbally explained.

The next section describes in detail an empirical study of the value dimensions used by some British architects which clearly distinguishes groups in terms of the distinction outlined above.

Method

The sample of architects interviewed was not selected in any statistically systematic manner, but covered four occupationally distinct groups within the architecture profession and within each group an attempt was made to include a range of types from the office junior to senior partners.

The groups were as follows:

Public:	local authority architects and new town (19)
Private:	small and medium sized offices (22)
Research:	architects in research and development (9)
Teaching:	range of architects mostly from universities (19)

It was unfortunate that no architects working for contractors were included as a later study by Salaman (2) suggested that this group would have a "slightly different value system". However the historical distinction in terms of the development of the profession between public and private architects was of the main interest in this study (3). The sample is small and unrepresentative but the intention was merely to show how ideological dimensions could distinguish particular groups within the profession without suggesting that these are the only appropriate ones (4).

Five questionnaires were given to each architect; each one measured a different level of architectural ideology - the AVL measures the architect's general social values, the professionalism items measure his attitude to work, the design items measure his personal philosophy and the simulated decisions isolate specific attitudes to details of design. The exact details and background of the questionnaires used are given in Appendix I, p.17-2-6 Factor analysis (principal component method) was used to isolate distinct dimensions which were then examined using correlations (Product-moment type) between scores on simple Likert scales. Biographical variables were also related to the attitudinal dimensions in order to make clear the fact that the dimensions can be best described in terms of the types of architects who use them.

The Dimensions Isolated

Two major dimensions were isolated and the components of each are shown in Figures 1 and 2 below.

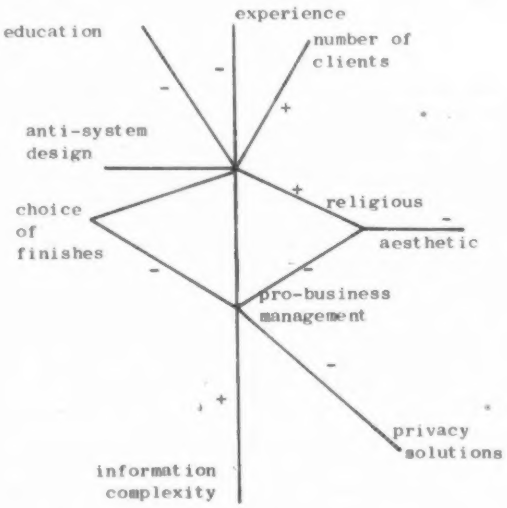

Figure 1. Dimension one : pragmatic

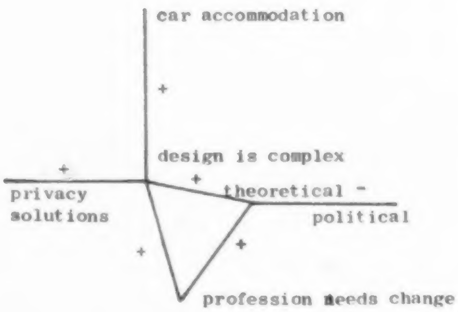

Figure 2. Dimension two : rationalist

The interconnecting lines are proportional to strength of correlation where the shorter the line is the greater is the realtionship. The exact meaning of each variable can be found by reference to Appendix I and II: the direction of the relationship is indicated on the diagram.

The first factor explains a larger amount of the common variance than the second, i.e. 27.5% compared with 25.5%. When this fact is taken into account along with the strength of the correlations we can see immediately that Dimension One is the larger in size but loosely formed while Dimension Two is smaller in size, but very tightly cohesive. When these results are related to the groups of architects (as in Figure 3 below), we see that the first dimension refers more to the largest group, the practitioners and the second one more to the smallest group, the researchers.

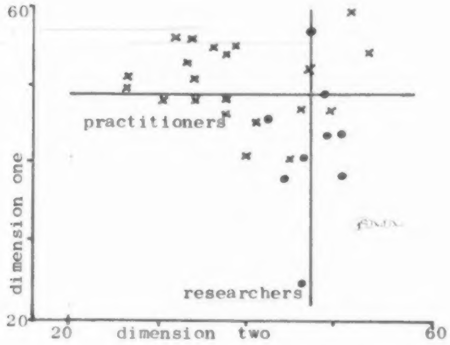

Figure 3. The groups which best represent the dimensions.

One point that must be made clear is that while the two dimensions are not polar opposites, and are based on fundamentally different premises, some aspects of each are related. For example, the religious and theoretical values which form a major part of Dimensions One and Two respectively are in fact inversely related (5); also the number of privacy solutions generated is positive in the second dimension and negative in the first.

The first dimension has mystical overtones and respects the status quo in the architecture profession and in design theories, the second is more scientific in tone, enquiring after universal truths and shunning political manoeuvres while at the same time emphasising the need for change in the professional institution and the complexity of the design process (see the exact items for each dimension in Appendix II). Office education rather than that of the University relates to the main dimension; in Oakeshott's terminology we can say that "traditional" knowledge rather than mere technical facts are being stressed by the pragmatist. This means that the architect who is against sytematic design method and who stresses the business aspects of his job does so from an experience of a wide variety of design work and clients. It is clear that involvement is an activity reinforces traditional values which corroborates Sewell's (6) results with his study of engineers and public health officials where he shows that seniority is negatively related to the perception of the need for change. That is, the more influence the architect has, the less likely he is to use this power to introduce positive new ideas. The other results indicate that architects who see their job primarily as a business prefer cheap and non-durable finishes. The highly pragmatic architect is not unduly concerned with lasting quality in his design, especially in comparison with his rationalistic counterpart who chooses expensive, massive and rigid solutions to the car accommodation problem. Another positive aspect of the first dimension is the existence of a wide range of information categories. It is interesting that a loosely structured approach to design decision making generates a profusion of information types while at the same time does not increase the range of design solutions provided to suit a particualr concept (privacy). Of the two dimensions the first has a broad base but is probably restricting while the second is more narrowly based but accommodates flexibility.

This description of the two dimensions is intended to show that dimensions one and two contain elements of what was described earlier as pragmatism and rationalism respectively. This interpretation is confirmed by the way the groups relate to the dimension. Since both dimensions have differences in structure and in content they combine the ideas of a political ideology and a cognitive map; the description styles of thought seems to convey both the psuchological and the cultural meaning of the dimensions.

Group differences on the Dimensions

The mean scores of all groups on each dimension was calculated and the significance of the difference calculated by t-tests. The main point of these results is that all the groups can be considered to be distinguished by both dimensions except the teachers and practitioners who are similar in terms of one.

It can be seen from Figure 4 below that the validity of the dimension is confirmed by the group's relationships to these.

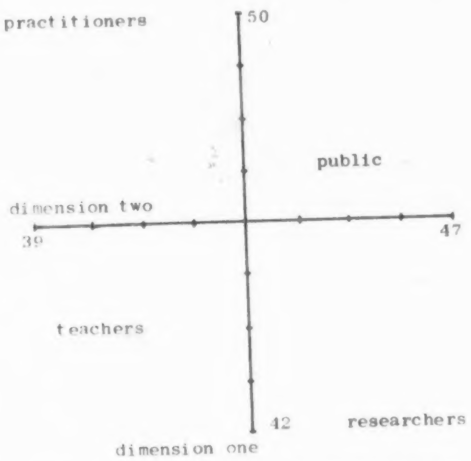

Figure 4. The relationship of groups to the dimensions.

Architects in private practice are like Oakeshott's "men in a hurry", they are dealing with the day-to-day administration of producing actual designs and buildings and without the time to take a long-term view of every problem they are guided in their job by organisational efficiency and past experience. Researchers on the other hand, are likely to be rational in approach and interested in the complexities of design problems; their job is largely analytical in that they break down a design problem into parts and gather information on separate aspects of the problem. The local authority or public group have a more ambiguous role in architecture; they are neither pressured by business considerations like making a profit, nor are they completely free to analyse problems; this in-between position is reflected by their position mid-way on both dimensions.

These differences between groups can be related to traditional measures of conservatism. The typical architect in private practice conforms well to the picture of the conservative personality as measured by psychologist Eysenk (7) and political scientist McLosky(8). The official architects are more ambiguous than the above measures allow for but are well described as the "traditional socially responsible personality" outlined by Berkowitz and Lutterman (9). The researcher on the other hand has a more highly structured and ideologically based system of beliefs which conforms to the picture of a"constrained ideologue" set forth by Converse (10) and empirically defined by McLosky (8) as the elite group of American political activists. Since the researcher is trying to establish paradigms (11) in architecture and he has in a way become isolated from the practical activity, his work is a sort of superstructure in the profession; he is trying to set the context in which action can take place in the same way that political scientists set the context of political activity by analysing politics.

Since institutionalism tends to confirm and re-enforce the held values we can see that certain groups in architecture will continue to have belief systems which are really polar opposites, e.g. the researchers and practicioners here. The activities of design and research may be theoretically complementary but in a social context they are contradictory (12).

The most interesting point about these results is that they show quite clearly that all architectural groups have implicit political allegiances in what they might feel are their purely architectural values.

Implications of the Results

Further research projects have been carried out and others are in progress, which confirm these results in general and produce much more detailed information particularly on the changing structure of the dimensions for architectural students. Instead of describing these results here, I will outline, by giving some examples, the way in which the ideas developed can be used to analyse particular problems in architecture.

In Britain the professional institute, the RIBA gives recognition to schools of Architecture after a two-day examination by a Visiting Board. It is stated policy to encourage schools to develop their own specialism under the assumption that incoming students can choose a school to suit their needs. In this way, schools develop areas of interest, like computer research or sociological analysis or encourage complete freedom in determining projects. Now an important point about the value dimensions described above, is that they should relate to design creativity. In a very comprehensive study, McInnon showed that highly creative architects held apparently contradictory values; that is the theoretical and aesthetic AVL (13). The rationalist and pragmatic dimensions respectively contain these values; further, the structure of the two dimensions suggests that their dichotomy may relate to psychological ideas of cognitive complexity-simplicity and the convergent-divergent functions, both of which are methods of analysing an architect's approach to design used in creativity research.

What I am suggesting is that value structures are important in design education and that any one school and any good architect must try to develop both sets of values highly. This is recognised as an aim by some schools but their means of achieving this end is often to portray a range of different approaches. The point is that these all tend to be rationalist in style and what seems to be needed is a strong mixture of a scientific and a practical approach; the simulated design project by which most schools still operate is clearly neither one nor the other. This research does suggest that excessive specialisation in the architectural profession will have an adverse effect on what is traditionally known as design.

Another implication of the R.I.B.A. policy when it is considered in the light of these results is that the visiting board, which questions staff and students to ascertain the school's educational policy responds to explicit ideology. In effect, this board must come to the conclusion that unless a policy can be clearly stated, it must be suspect. Here we must remember that the central point about the pragmatic approach is that all rules are abridgements of an activity and that full knowledge of what is going on in a school must be more than technical. It is clear that the nature of the board and the RIBA's push for architecture schools to join Universities denies the validity of the practical approach in architecture. Using the terminology of creativity research, we can see that since the demise of the Beaux Art stylistic influence on design the divergent function in architecture education is increasingly being superceded by the pseudo-scientific approach and there has emerged a self-consciousness about more intuitive ways of solving problems. This self-consciouness has been noted and discussed by both systematic design apologists, like Alexander(14) and by those stressing the need for complexity and ambiguity, like Rappoport(15).

In the United States where there is no such powerful professional institution as in Britain, but it is likely that since elite groups express ideologies most explicitly (16), the top schools for architecture will be those which stress a rationalistic approach. American political science research suggests that elite groups in politics have highly constrained and structured value systems and we could infer the same about architecture. While most writers assume that logically cohesive value structures are better than those which are diffuse and open Brown (17) has shown quite clearly that this is because that structure represents in America, the dominant idea of liberal democracy. When, however, elitist ideologies are interpreted in psychological teams, it is clear that their narrow base, inflexible structure and cognitive simplicity are not the best prerequisites for either creative politics or creative design.

Conclusion

I have outlined a theoretical approach to the study of design decision-making and tested this empirically by the study of British architects. I then try to show how this kind of analysis can be used to examine current political problems in architecture. The analysis is necessarily sketchy and more in the nature of an exploratory study but it does provide an approach to research in design decision-making which is rigorous and comprehensive and without being too abstract or mathematical.

The empirical study is obviously limited by the size and scope of the sample and it is not really possible to generalise from the groups chosen in this fieldwork. Further research will expand the scope and test the validity of the kind of dimensions found here for more groups, while at the same time relating these to job satisfaction. The relationship between the value dimensions and measures of creativity like cognitive complexity, divergence/convergence, stereotyped and syllabus bound-free attitudes to work is also being explored in studies with students. A study of changes in student values has provided more detailed information on the relationship between various measures of value structure and educational and office experience for architecture students. These are the areas of research being explored at the moment.

The important fact about this type of research is that it is predictive and this is prbably the main criteria in deciding which areas are worthwhile following up; it means in effect concentrating on architectural education and political policy in the profession which are the two main areas where there is greatest need for more information on how to achived stated aims. For example, the results of my research allow us to make statements like, better design is more likely to result from a team of generalist architects all with highly developed theoretical and pragmatic values than from a team of mixed generalists and specialists or from an interdisciplinary team; and statements like, if you are interested in allowing architects to develop their own specialist interests and skills this will be likely to reduce their capacity for producing good design. And so on.

My concern with design as it is traditionally known in architecture is a reaction against systematic design method research which is not primarily concerned with helping architects to design better buildings, even though it might do this indirectly. And in reacting against this type of research I do not intend to give the impression that personal values and their structure are the main determinants in the design process (though they may be) but it does seem that design method research ignores two important facts about decision making. Firstly, it assumes that values and facts (information) can be clearly distinguished at different stages in the process while political science research has long made it quite clear that personal values modify conflicting information to fit in with strongly held opinions (18) like many of the architectural ones I have been discussing. Secondly, design methods theorists often assume a model or pattern of decision making which is sequential or linear where as the little research that has been done suggests that decision making, like that which takes place in architecture is configural or non-linear in pattern (19). For these reasons, among others I have tried to emphasise those aspects of architectural design which are not at the moment central in decision making research.

Notes

(1) OAKESHOTT, M. Rationalism in politics and other essays. Methuen, London 1962. The pragmatic-rationalist distinction is one developed initially by Oakeshott and is fundamental to his philosophical analysis of politics; the above essay is a good introduction to the kind of analysis developed in this paper.

(2) SALAMAN, G. Architects and their work. Architect's Journal, 21 January, 1970, p188-190.

(3) This is the main historical distinction outlined KAYE, B. The development of the architectural profession in Britain. Allen and Unwin, London 1960.

(4) A validating study of a representative sample of the profession is in progress.

(5) r = -0.55

(6) SEWELL, D. Crisis, conventional wisdom and committment; a study of perception and attitudes of engineers and public health official's Environment and Behaviour, March 1971, vol.3, no.1, p.23-60.

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(12) MARKUS, T. Design and Research; Co-operation not conflict. Conrad, July 1969, vol.2, p.35-38.

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(14) ALEXANDER, C. Notes on the synthesis of form. Harvard University, 1966.

(15) RAPPOPORT, A. House form and Culture. Prentice Hall, 1969.

(16) See LIPMAN, A. Architectural Education and the social committment of British Architects. The Sociological Review, 1970, vol.18 no.1, p.5-27, for a discussion of the relationship between explicitness in ideology and elite groups.

(17) BROWN, S. Consistency and the persistence of an ideology. Public Opinion Quarterly, vol.34, 1970, p.60-68.

(18) HYMAN, H. and SHEATSLEY, P. Some reasons why information campaigns fail. MACOBY et al (eds) Readings in Social Psychology, Holt, 1952.

(19) SLOVIK, P. Analysing the expert judge: a descriptive study of a stockbrokers decision process. Journal of Applied Psychology, August 1969, vol.53, no.4, p.255-263.

APPENDIX I - The Test Details

(i) The Allport Vernon Lindsey Study of Values. This test is a measure of individual's orientation to life in terms of the emphasis placed on six areas - the theoretical, political, economic, social, religious and aesthetic. Despite methodological disadvantages, in particular, the scoring by means of a profile, the test has previously been used in a pilot study with students where it did produce interesting correlations with measures of simple design choices. Initially, the test had been chosen because of results of McInnon's (13) study of American architects which suggested that certain combinations of values distinguished groups and related to creativity in design.

(ii) / ...

(ii) The attitude statements. Two broad areas of design theories and professionalism were covered and measured using the architect's response to over sixty attitude items. In each area, certain issues were outlined but at the same time, it was possible to infer how an individual architect's approach to a combination of these issues could be described as a coherent philosophy. In the professional sphere, the main topics were the extent to which the architect saw his job as a business, his concern with the notion of service to society and the degree to which he claimed for himself, the traditional role of the expert and leader in the design team. The main concern in asking questions about design theories was the extent to which the architect viewed the design process as systematic rather than intuitive and personal; this covered the idea of mysticism, design as unteachable, reliance on a classical humanism and an informed heuristic. Items balancing these on the positive approach to systematic design concentrated on the use of design method techniques, dimensional co-ordination and computer applications.

(iii) The simulated design decisions. These measures analysed the architect's response to simple simulated design situations in terms of the same kind of dimensions, as the attitude statements - i.e. the architect was given a score, according to how much or how little he utilised the concept under consideration. Only four of the measures produced correlations with other scores and these are described below:

(a) Choice of Materials in Housing. The architect chooses materials for a specified client from a range of window types, door frames, and cladding materials. The variables had previously been pre-coded in terms of relative cost and traditionality so that each architect's choice could be described as a scale position on a cummulative score which rose in cost and degree of unconventionality.

(b) Information complexity. The architect was asked to act as a consultant in a specified type of housing design for a particular client and had to write down all the different types of information he would need before commencing the work. This information was then content analysed and each architect was given a score according to the number of different types of information he requested. That is, the higher his score, the wider the range of information requested.

(c) Choice of car accommodation. This measure concentrated on the architect's preference for a type of car parking, and here again, the score was given according to a previously worked-out cumulative scale. This time, the scale items - (e.g. hardstands, multi-storey car parks etc. all at different costs) rose in terms of building scale, massivity of the construction cost and the totality of concept involved. (The costs were included on the questionnaire).

(d) Complexity of privacy solutions. This was another open-ended measure where the architect was asked to illustrate to students how privacy could be achieved at three different levels of density and rise in housing. The solutions were content-analysed and categories evolved as in the information question, so that each architect could be given a score reflecting the complexity or the range of solutions produced. Therefore, the more different solutions prepared for each level, the higher the architect's score would be.

(iv) The Biographical Controls The main factors in this questionnaire were age, variety, experience in housing design - measured in terms of variety of clients and design types, the degree of academicism of architectural education - measured, using a scale going from office full-time through part-time technical colleges to university combined with a score for number of degrees held; and extent of involvement in professional groups, measured by membership.

APPENDIX II - Attitude items showing factor loadings on each dimension.

Dimension 1 : pragmatic

Design : anti-system design.

New towns can be designed to form integrated communities. (-.69)

Design problems have logical solutions. (-.65)

Dimensional co-ordination is the key to flexibility design. (-.60)

All design problems should be solved in a series of stages. (-.56)

Architects can be trained to apply a method which logically solves all problems. (-.52)

Environmental design is of the greatest importance to man's happiness. (-.44)

Environmental design is a physical reflection of society's aspirations. (-.43)

Professionalism : pro-business management

An architect must be a good administrator,(+69)

All buildings which require planning permission ought to be architect designed,(+.64)

The architect must always be leader of the building team, (+.57)

Business management is the key to establishing a successful practice in architecture, (+.50)

Architects must be able, above all, to organise other people, (+.48)

The best architects are generally good business men, (+.43)

All the best architects in Britain are in the RIBA, (+.42)

% Common variance = 37.5   Alpha = 0.725

Dimension 2 : rationalist

Design is complex

The way good designers get their results can not be explained verbally, (+.68)

Environmental design should aim to affect people's behaviour as little as possible,(+.55)

The most important quality for the potential architect is imagination, (+.55)

Compromising conflicting requirements is a good description of architectural design, (+.47)

Design is intuitive, (+.47)

Badly designed housing estates are the main cause of juvenile delinquency, (+.45)

Design is an inherently haphazard process, (+.39)

Profession : needs change

Architecture is a badly paid profession,(+.62)

The RIBA represents the interests of employers and not workers, (+.60)

The best way to obtain design work in architecture is through informal contact, (+.51)

The most successful architects are always clever politicians, (+.43)

The RIBA is basically no different from a Trade Union, (+.42)

Architects should be able to advertise their services,(+.37)

The RIBA does not often make mistakes and generally it is on the right lines,(-.43)

Common variance = 25.5   Alpha = 0.64

GROUP COMPOSITION IN URBAN PLANNING:
Single Discipline Research and Design / Interdisciplinary Research and Design

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Abstract

The efficacy of a multidisciplinary group is mediated by a number of factors including personality, intellectual functioning, group size, leadership and group composition. In urban planning, many groups must be multidisciplinary but little is known as to how to select a group, its component disciplines, its probability of successful research and design and goal-policy evolutionary tendencies. The purpose of this research was twofold: (a) experimentally manipulate one of these variables -- group composition -- in an attempt to determine its effects on the functioning of multidisciplinary urban planning; (b) to suggest further research which needs to be conducted to better estimate the overall efficacy of the multidisciplinary research and design strategy.

Statement of the Problem (1)

Many urban planning efforts in both research and design (2) are made with teams of people composed of mixes of disciplines, personalities and leadership qualities. Groups become assembled as a result of friendships, kinship, profit and expediency. Planning tasks are often considered as problems, problems to be uncovered and problems to be solved, when often a missing discipline's viewpoint may do much to dispel consternation and concern. (3) Often a problem to one discipline may not be a problem to another. By contrast, in some planning tasks irrelevant disciplines to the task are present. A proper "mix" of those within a team should be considered as an important aspect of any research or design process. When a reasonable team is established with regard to group composition, then a higher probability of success may result.

At times urban planning problem identification may be sought; in this instance a mix of disciplines may be engineered to match both the problem-setting and the typology of the planning problem. Some urban planners and architects like Archibald Rogers believe that all problem-settings and problem-typologies require a design concept team of professional specialists. (4) Implied in the concept of teams of professional specialists is an assemblage of actors usually with little knowledge of their efficacy in group dynamics. Having a mix of specialists is often intuitively stated as desirous because each investigator or member of the planning task brings his own systhesis of relevant theories to the task or problem to be solved (5); especially since planning ecological, social and psychological goal-realization is accepted to leave such little margin for error. Many urban planning tasks are attempted with improper definition of the planning problem or an improper decomposition of the components of the problem. These latter aspects are often overlooked in the formation of planning groups in order to pursue a "conventional wisdom" now biased toward interdisciplinary problem solving. Some of these kinds of planning activities may better be attacked by groups comprised of homogeneous abilities with heterogeneous attitudes. (6) The appeal of interdisciplinary group formation is often that the outcome of the urban planning activity will be considered more valid if the group is composed of many individuals each prestigious in his own discipline. If a man with such impressive credentials could find time and energy to be involved with others in this planning task, then the outcome must be reasonable - both because he is involved and because he endorses the outcome. Another factor promoting bias towards interdisciplinary groups lies in the nature of our pluralistic society. Many groups with differing goals, and actors in decision-processes, form themselves and are assembled by others. Since the "wrong" people and the "wrong" group composition may often appear (politically) without any hope for premeditated selection of individuals, by amassing an interdisciplinary planning group diverse individuals may be arrayed to cope with other diverse viewpoints increasing the acceptance factor of the plan(s).

Urban planning tasks have some unique aspects: some tasks are specifically design tasks and others are research. Design consists of going from the general need to the specific concrete solution(s). Research consists of going from unorganized facts and nebulous questions to a generalization or a new understanding of certain phenomena. Planning, as an activity, concerns itself with free movement between research and design tasks and both kinds of tasks contain elements of the other. These definitional differences have been delimited for the sake of conceptualization of our experimental designs, and the problem devised (Aplendix A) inherently contains some elements of design with an emphasis upon research planning tasks. These authors believe that research planning tasks are more likely to be the most needful of group involvement. Professional planning attitudes appear to reinforce our beliefs. (By contrast, design may effectively be the willful act of an individual.)

In urban planning activities, there is increasing realization by members of the planning community that specialization by planners may be a counter-productive, inhibiting trend. Some examples might be: physical planners trained in physical design who design an aesthetically appealing but socially disfunctional suburban neighborhood; urban politicians who arrange policy change for one social group without regard to that groups' interaction with other social groups; or engineers who design a dam with little regard for the effects their project will have on ecology.

Fortunately in most instances, urban planners have been aware of the need for multi-dimensional, cross-disciplinary analysis and synthesis. Some planners are trained in tools and techniques of science and as members of the scientific community are disseminating their knowledge to attempt to counter a single-disciplin approach; namely by promoting interdisciplinary strategies. The planners' concern for adequately considering the relevant aspects of his problem setting may be considered part of a "zeitgeist" pervading many disciplines. This trend may be evidenced in the "hard" sciences or physical sciences, by emergence of a number of "think tanks." In the "soft" sciences, or social sciences, this approach has been advocated by a number of sociologists (e.g. Robert Boguslaw, 1964) and psychologists (e.g. Sherif & Sherif, 1969).

The impetus for a multidisciplinary approach to problem resolution, design and research stems largely from the weaknesses inherent in the traditional single-minded approach. Specifically, critics of the single discipline approach argue that such a research and design strategy focuses on only one small aspect of a problem, and neglects the ramifications this type of solution will have on a total system. Advocates of the multidisciplinary approach believe that the identification of problems and the strategies employed in the resolution of these problems can be enhanced by turning from a research strategy wherein a single emphasis and methodology is used to a strategy that utilizes the expertise and methodologies of a number of disciplines.

It is important to note, however, that the efficacy of a multidisciplinary research strategy is an empirical question. While this approach is intuitively appealing, it is not at all clear whether or not this approach represents the "one best way." One can identify at least two factors underlying this skepticism. First, there may be some problem areas that can be more efficiently and effectively dealt with by using a single discipline approach. Second, research concerning factors that mediate the outcome of problem-solving groups is in an equivocal state.

With respect to these two factors that one should consider when attempting to decide which research strategy is most efficacious for a given problem, the first has aroused little research interest whereas the second has been of some concern for a number of years. A vast quantity of research has been directed toward factors mediating the outcome of group problem-solving. Some of the variables that have received a good deal of attention are the structure of the personalities of the individuals involved; the size of the group; the leadership of the group; and the composition of the group. Reviews of research conducted in these areas are presented in Collins and Guetzkow (1968), Davis (1969), Hare (1962), and Marlowe and Gergen (1969).

Of all the factors that mediate the outcome of group problem-solving, the composition of the group is a very important variable--particularily when one is reviewing this literature in an attempt to reach a decision concerning whether a multidisciplinary or a single discipline approach is more advantageous for a given problem.

Group composition refers to the "mix" of the group members; that is, the heterogeneity of the skill and orientations of the group members. Urban planning efforts, by their nature contain elements of physical design, economics, social-psychology and others. Planners themselves may be thought to be heterogeneous in attitude, but still show some signs of insecurity during their planning task completion concerning their individual limitations. Numerous investigators have attempted to answer the question: Should a group be heterogeneous or homogeneous in order to perform in an optimal fashion? Probably, a homogeneous urban planning group may be considered as comprised of planners (those with graduate education in urban planning). However, most urban planning groups are often heterogeneous. Generally speaking, research in this area suggests that heterogeneous groups yield solutions that are higher in quality than homogeneous groups. However, heterogeneous groups generally take longer to reach consensus and are afflicted with greater internal turnoil (Davis, 1969, Chapter 4; Collins & Guetzkow, 1964).

Therefore, the answer, based on previous research, concerning which type of group composition is best is that it depends: It depends because, while heterogeneous groups have increased problem-solving potential when compared to homogeneous groups, heterogeneous groups are also more likely to have difficulty building interpersonal relations among the members that are conducive to problem-solving (Collins and Guetzkow, 1964, Chapter 5).

If the members of a heterogeneous group can work out interpersonal communication difficulties in a relatively short period of time then the output of such a group will be superior to that of a homogeneous group. However, if the members of the group are unable to communicate effectively then a homogeneous group will generally prove most satisfactory and efficient.

Purpose of this Research

The efficacy of a multidusciplinary group is mediated by a number of factors including personality, intellectual functioning, group size, leadership and group composition. In urban planning, many groups must be multidisciplinary but little is known as to how to select a group, its component disciplines, its probability of successful research and design, and goal-policy evolutionary tendencies. (7) The purpose of this research was twofold: (a) experimentally manipulate one of these variables -- group composition -- in an attempt to determine its effects on the functioning of a multidisciplinary group; (b) to suggest further research that needs to be conducted to better estimate the overall efficacy of the multidisciplinary research and design strategy.

Hypotheses

Hypothesis I: Heterogeneous groups will display more internal conflict than homogeneous groups.

Hypothesis II: Heterogeneous groups will yield higher quality end-products than homogeneous groups.

Method

Subjects

The subjects used in this study consisted of fifty graduate students enrolled at Oklahoma State University during the spring and fall semester of 1971. The subjects were drawn from the physical sciences (math, physics, engineering), biological sciences (zoology, biology, physiology), and social sciences (psychology, sociology, business). It should be emphasized that the subjects were not selected in a random fashion; but rather, on the basis of their willingness to take part in the experiment as well as the constraints imposed by the research design. The design of the study is presented in Figure 1.

HETEROGENEOUS GROUPS
(n = 20)

Four 5-man groups, each group containing representatives from physical, biological, and social science.

HOMOGENEOUS GROUPS
(n = 30)

Two 5-man troups from physical science; Two 5-man groups from biological science; Two 5-man groups from social science.

Figure 1. Research design employed in investigation of single / multidisciplinary planning groups.

Originally, the investigators had planned to use five 5-man heterogeneous groups, five 5-man homogeneous groups from the "hard sciences" (e.g. math, physics, engineering), and five 5-man homogeneous groups from the "soft sciences" (e.g. sociology, psychology, business). However, due to the difficulties encountered in attempting to recruit graduate students to participate, without financial reimbursement, in this study the authors were forced to limit the number of groups involved.

Instruments

The instruments used to collect data in this experiment consisted of a problem sheet and an interaction coding sheet based on Bales' (1950) Interaction Process Analysis. The problem sheet outlined the problem for the subjects and told them what they were to do. A copy of this is enclosed in Appendix A. The interactions among the group participants were recorded by the investigators using Bales' Interaction Process Analysis. This system provides for the recording of both positive and negative events that pertain to the social-emotional and task activities of the groups. A copy of this form is enclosed in Appendix B.

Procedures

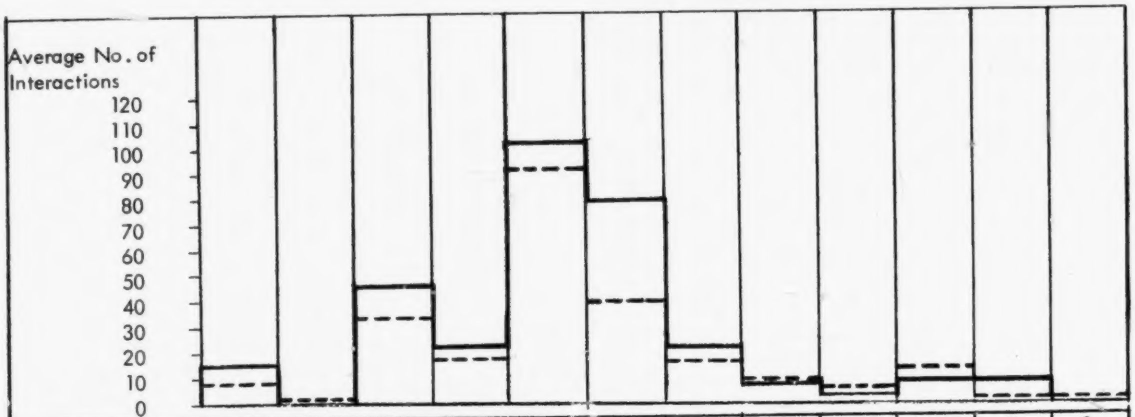
The procedures employed during the course of this study were straightforward. When the subjects arrived at the pre-designated time they were met by the experimenter, introduced to one another, and seated around a table. The investigator then acquainted them with the problem, told them they would have approximately one hour in which to work on the problem, and then instructed them to begin. After fifty minutes had elapsed the experimenter interrupted the group, told them to summarize their work, and to specify the problems, solutions, and opportunities they had identified during the course of their discussion of the problem.

Results

Hypothesis I

Heterogeneous groups will display more internal conflict than homogeneous groups.

A graphic display of the results obtained in conjunction with the first hypothesis is presented in Figure 2.



	1	2	3	4	5	6	7	8	9	10	11	12
homogeneous	9	0	34.0	18.3	92.0	39.3	17.0	9.3	5.3	13.3	0	0
heterogeneous	14.7	0	43.0	20.7	102.6	77.3	21.7	8.3	2.0	7.7	7.7	0

IPA Category (8)

Figure 2. Results of Interaction Process Analysis of homogeneous and heterogeneous groups.

With respect to the IPA analysis of the interaction among the homogeneous and heterogeneous groups, the mean number of interactions among members of heterogeneous groups was 309.3, while the mean number of interactions among the members of homogeneous groups was 244.3, a difference that was found to be statistically significant at the .01 level of confidence. (9) However, none of the results displayed in Figure 2, including those pertaining to IPA category six, were significant when tested individually.

Hypothesis II

Heterogeneous groups will yield higher quality end-products than homogeneous groups.

A contant analysis of the end-products obtained from all of the groups is presented in Table 1. Note that "end-products" is defined as the problems identified, solutions proposed and opportunities suggested in association with a group's discussion of the problem.

(see Table 1. next page)

Interpretation of the Results

Discussion

The results of the foregoing data analysis present a rather ambivalent state of affairs. The investigators had expected to reject the first hypothesis and retain the second. In reality, however, both were rejected.

The first hypothesis -- that heterogeneous groups would display greater internal discord than homogeneous groups--was rejected on the basis of an analysis of the interactions among the members of the groups. The heterogeneous groups, on the average, did evidence a greater number of interactions than the homogeneous groups. This is precisely what one would expect from groups embroiled in intra-group conflict. However, when these gross results were subjected to a more detailed analysis, the differences between homogeneous and heterogeneous groups disappears. The data presented in Figure 2 suggests the heterogeneous groups had not more difficulty establishing effective and productive interpersonal relations than did the homogeneous groups. None of the differences displayed in Figure 2 were statistically significant, including those associated with IPA category six.

It should be emphasized that the IPA profile of a group marked by a great deal of inner turmoil, hostility, and poor interpersonal relations would have low scores in categories one through three, or the categories pertaining to positive social-emotional relations (e.g. agreement, tension release, and displays of solidarity). Conversely, such a group would also be marked by high scores in categories 10 through 12, or the categories

		$\overline{X}$ No.	Quality of Outcome		
			Fair	Good	Very Good
Problems Identified	Homo.Gps	8.3	0.0	6.0	2.3
	Het. Gps	5.3	0.0	3.3	2.0
Solutions Proposed	Homo. Gps	2.3	0.3	1.0	1.0
	Het. Gps	5.7	0.7	3.3	1.7
Opportunities Suggested	Homo. Gps	4.0	1.0	1.7	1.3
	Het. Gps	1.0	0.0	0.7	0.3

Table 1. Content Analysis of Outcome from Homogeneous and Heterogeneous Groups.

pertaining to negative social-emotional relations (e.g. disagreement, displays of tension or antagonism). However, the homogeneous groups were lower in the positive social-emotional categories than were the heterogeneous groups. Furthermore, the heterogeneous groups did not differ significantly from the homogeneous groups in the negative social-emotional categories.

The second hypothesis--that heterogeneous groups would produce higher quality end-products than homogeneous groups--was rejected on the basis of the content analysis displayed in Table 1. The investigators had expected that, assuming they could establish effective interpersonal relations, the heterogeneous groups would uncover more problems and suggest higher quality solutions for those problems than the homogeneous groups. However, the data suggest that neither the quantity nor the quality of the problems identified, solutions proposed, and opportunities suggested differed significantly between the homogeneous and heterogeneous groups. The homogeneous groups identified, on the average, more problems and suggested more opportunities associated with the task, whereas the heterogeneous groups proposed more solutions. However none of these quantitative differences were statistically significant, nor were any of the qualitative differences shown in Table 1 significant.

Conclusions

The first conclusion to be drawn runs counter to much of the previous research in the area. This conclusion is that heterogeneous groups are not always prone to difficulties in the area of interpersonal relations. The data clearly suggest that neither type of group had an especially difficult time building effective interpersonal relations. Both groups were apparently able to concentrate on the task at hand rather than dissipating their energies on interpersonal infighting.

This conclusion must be moderated by two facts. First, the situation in which the participants found themselves was an artificial, laboratory environment . The artificiality of the situation, together with the fact that the subjects were continually observed, probably produced what the psychologist calls "demand characteristics;" that is, pressure on the subjects to behave exactly as the investigator told them to behave. Demand characteristics generally reduce the variability of a subject's behavior.

The second conclusion that may be drawn from the results of this study sheds some doubts on the efficacy of a multidisciplinary approach to problem-solving. The results summarized in Table 1 leads the investigators to conclude that the quantity and quality of the heterogeneous groups' performance was no better than the performance of the homogeneous groups. This suggests that, while a multidisciplinary approach may be intuitively appealing, such an approach may not always be justifiable.

This second conclusion is particularly damaging when viewed in terms of the outcome of the first hypothesis.

One would not expect heterogeneous groups to perform better than homogeneous groups when the interpersonal relations among the members of the heterogeneous groups were poor. However, in this research the interpersonal relations in the heterogeneous groups were as good as those in the homogeneous groups, yet the heterogeneous groups still did not outperform the homogeneous groups.

This second conclusion, like the first, must be tempered by several considerations. First, the one hour time constraint imposed on the groups may have restricted both the quantity and the variability of the outputs of the groups, particularly the heterogeneous groups. Second, the artificiality of the situation should be considered as a possible source of contamination with respect to this conclusion as well as any others drawn from the study.

To reiterate, the analysis of the data collected during the course of this study suggests that heterogeneous groups may not always be superior to homogeneous groups in the area of problem-solving. The impact of these conclusions should be obvious. The trend toward multidisciplinary research and design groups may not yield outputs that are greater in either quanity or quality than single discipline research and design groups. In fact, such heterogeneous groups could conceivably by detrimental, particularly when a problem calls for the expertise of one discipline and/or there is reason to believe that the interpersonal relations of a prospective multidisciplinary research and design group will be poor.

Suggestions for Future Research

A good piece of research should do at least two things: I should provide the reader with insight into the area under consideration, and it should suggest additional work that needs to be done. There are a number of factors that have been touched upon in the present study that require additional research.

One such factor is the element of time. In the present study the subjects were only given one hour in which to interact. This, no doubt, contributed to the artificiality of the study, and may have restricted the quantity and variability of output of both groups. A more adequate research design would require subjects to meet several times (e.g. five one hour meetings) to discuss the problem and formulate solutions.

Another factor that needs even more consideration is the task or problem on which the subjects work. The problem used in the present study was chosen because it was of general interest and widespread concern, and did not call on the special talents of any one discipline. However, it is quite probable that there are certain tasks that are inherently more suitable for the multidisciplinary approach to research and design whereas other problems are probably more suited to a single discipline approach.

APPENDIX A - TASK ASSIGNMENT

> Assume that funds for the SST (supersonic transport commercial aircraft) have been secured from Congress.
>
> Discuss this project's problems and opportunities.
>
> Identify as many problems, opportunities and their solutions as you can.

APPENDIX B - IPA CODING SHEET

(1) SHOWS SOLIDARITY:
raises others status,
gives help, reward,
jokes.

(2) SHOWS TENSION RELEASE:
shows satisfactions

(3) AGREES:
shows passive acceptance, agrees,
complies, concurs,
understands

(4) GIVES SUGGESTION:
direction, implying
autonomy for other

(5) GIVES OPINION:
evaluation, analysis,
expresses feelings,
wish

(6) GIVES ORIENTATION:
information, repeats,
clarifies, confirms

(7) ASKS FOR ORIENTATION:
information, repetition,
confirmation

(8) ASKS FOR OPINION:
evaluation, analysis,
expression of feeling

(9) ASKS FOR SUGGESTION:
direction, possible
ways of action

(10) DISAGREES:
Shows passive rejection,
formality, witholds help

(11) SHOWS TENSION:
Asks for help,
withdraws out of
field, laughs

(12) SHOWS ANTAGONISM:
deflates others status,
defends or asserts self

NOTES

(1) Research completed in association with The Multidisciplinary Studies Group -Genter for Systems Science, Oklahoma State University

(2) Asimow, Morris, "INTRODUCTION TO DESIGN, p. 44, Prentice-Hall; 1962, states that designing should not be equated with problem-solving. It is more like "problem-finding." The designer is presented, not with a problem, but with a "problem-situation."

(3) Many urban problems have been identified as being caused in part "by a lack of comprehensive thinking and foresight in the process of identifying, analyzing and solving problems related to the man-made and natural environment." Meyer, William T.; "Environmental Problem-Solving;" in JOURNAL OF SYSTEMS MANAGEMENT, Vol.22, no. 10; October 1971, p.22.

(4) Rogers, Archibald, "How to Combine Experts' Ideas and Citizens' Ideas and Your Own Professional Talents in Building an Environment That is Right for People," INNOVATION, Group for Technology Communication, Inc., N.Y.; 1969.

(5) Meier, Richard L.; "Exploring Development in Great Asian Cities: Seol"; AIP JOURNAL,: Vol. 36, No. 6: Nov. 1970, p. 379.

(6) Tirandis, H.C., Hall, E.R. & Ewen, R.B.; "Member Heterogeneity and Dyadic Creativity," HUMAN RELATIONS: 1965; 18(1); p. 33-55.

(7) Defined as: the propensity for policy and goal formulation attitudes developing in certain directions after a series of meetings.

(8) See Appendix B for IPA Category Definitions.

(9) The analysis was chi-square.

(10) The quality of outcome was determined by the two experimenters' subjective evaluation.

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COGNITIVE PERSUASIONS: ASSUMPTIONS AND PRESUMPTIONS

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Abstract

Cognitive persuasions are decision rule complexes that allow you to process information about the world. These complexes enable you to view and explain the world in a way that is meaningful. Different people use different decision rule complexes. These differences can lead to assumptions about the nature of reality that cause conflicts and presumptions about the nature of other people that lead to covert expectations.

Introduction

People with different points of view often disagree. Opposing attitudes or opinions appear to facilitate these disagreements. Differences in opinion, however, typically reflect more fundamental differences, differences in underlying assumptions about the world. Because these assumptions shape cognition, belief, opinion, and perception of the world, they will be referred to as "cognitive persuasions."

Cognitive persuasions are pervasive points of view. They consist of organizing principles which allow you to process information about the world while also reflecting the meaning you give the world. If conflicts occur between people with different cognitive persuasions, they would not arrive from simple differences in opinion, but rather from fundamentally different ways of processing information.

In this study two major cognitive persuasions will be compared. The first tends to analyze, reduce, quantify and objectify their view of and assumptions about the world. The second tends to synthesize, holise, qualify, and subjectify their view of and assumptions about the world. While both cognitive persuasions may experience the same events, they both explain and perceive these events differently. For example, the objectifier tends to reduce the multivariate event to a representative symbol and obtains an elegant equation. The perception is of a reduced and contained event. The subjectifier, on the other hand, tends to relate the multivariate event to the rest of the world and obtains a relational complex which can only be encompassed by a metaphor. The perception is of an expanded and infinite event. The conflict that may ensue from this difference is based on the assumption that each persuasion is perceiving the same thing but somehow missing the point.

In 1907 William James identified this cognitive dichotomy as Tough and Tender minds. Since that time Murray (1938), Allport (1955), Ansbacher (1956), Perls, Hefferline and Goodman (1951) and Maslow (1966) have attempted to comment on, or resolve the conflict in psychology. Psychological theorists of one persuasion have, nevertheless, tended to view those of the other persuasion with some skepticism. Since Tough and Tender minds have some precedent as a dichotomy in psychology, it is proposed that an analagous dichotomy may exist in other populations. It is further proposed that this dichotomy may cause conflict when people of both persuasions are required to make mutually responsive decisions.

In order to test these hypotheses, a diagnostic scale was developed to identify differences on this cognitive dimension (Organicism-Mechanism [OM] Scale). The scale was administered to two small groups of associated environmental experts. These two groups were having some difficulty making mutually responsive decisions. It was hypothesized that they represented the Tough and Tender minded cognitive persuasions and would score significantly differently on the OM scale.

Part One: Development of Instruments

The OM scale was developed to test for Tough and Tender mindedness. Each persuasion was defined as a pole on a series of bi-power dimensions. Questions for the scale were constructed on the bases of four such dimensions: Holistic-Elementistic, Dynamic-Static, Voluntaristic-Deterministic and Subjective-Objective. The Tender end of the continuum was represented by Holistic, Dynamic, Voluntaristic and Subjective while the Tough persuasion was represented by Elementistic, Static, Deterministic and Objective. Examples of questions from these dimensions are:

A. There are many ways to understand something. Given the following two possibilities, which one would you find more suitable for you?

1. To understand empathically from actually experiencing the phenomenon (subjective).
2. To understand scientifically from observing the phenomenon objectively and discovering the conditions necessary for its occurrence (objective).

B. Do you think that children will learn better if:

1. Each subject such as history, math, and English is taught thoroughly but separately from the others (elementistic).
2. There were no subjects, just information integrated around a central core such as the students' own interests (holistic).

C. G.B. Shaw once said "The brain will not fail if the will is in earnest." Do you feel that man's brain is directed primarily:

1. By his neural structures which have been laid down by his experience and heredity (deterministic).
2. By his free will (voluntaristic).

D. Which one of the following two words do you identify with more:

1. Matter (static).
2. Energy (dynamic).

Although a subject did have to make a choice that was forced, in answering these questions a request was made to weigh each answer with a number 1 (slightly agree), 2 (agree) or 3 (agree very much), which in effect created a six point scale from agree very much with the O (Tender) end of the continuum to agree very much with the M (Tough) end of the continuum.

After the instrument was constructed, an item analysis of the questions on these instruments was completed using 150 subjects. On this basis, twenty-six dichotomous questions were chosen for the final form of the OM Scale.

Part Two: Empirical Study

It had been rumored that there were a few communication difficulties and policy differences between Dept. A and Dept. B, two associated groups. Operationally defining this condition as conflict, it was decided to see if these two groups mirrored the same cognitive split found in other professional groups.

Method

Subjects: Twenty-two faculty (including administrators) and four staff. Ten faculty and two staff represented all but two faculty of Dept. B, while twelve faculty and two staff represented all but two faculty of Dept. A. The two staff members for each department were the only staff in the community who could be exclusively assigned to one department or the other without overlap.

Procedure: The OM Scale was distributed to all faculty and staff. After the total OM Scale was scored for each subject, it was divided into a number of separate subscales in order to measure some more specific factors. An Action-Belief scale was extruded made up of questions which asked subjects what they would do in a given situation as opposed to what subjects said they believed. A Holistic-Elementistic scale made up of questions which emphasized either a whole first or a parts point of view was also isolated from the larger OM scale. Subjective-Objective, Dynamic-Static, Voluntaristic-Deterministic, propensity to categorize, and an Educational Policy scale (made up of all questions specific to education from any of the other dimensions) were also extruded from the larger scale. The scores for each subject on each question were summed and averaged to obtain a mean score for each department on each dimension.

Results: There was a significant difference between Dept. A and Dept. B on their scores on the OM Scale. A turned out to be more Tender while B turned out to be Tougher. Using only the faculty scores, the difference was significant at the $p < .025$ level ($t = 2.20$, $df = 20$). If the two staff members are added to the score sum for each department, the significance level rises to $p < .005$ ($t = 3.589$, $df = 24$). The mean OM score for A was 24.01 while the mean OM score for B was 8.4 for the faculty alone. With the staff, the means change to 28.2 for A and 8.6 for B.

The Action-Belief subscale revealed that what A said they would do was very far away from what B said they would do (A mean = + 4.83, B mean = - 1.25), while what A said they believed (mean = 2.56) was much closer to what B said they believed (mean = 1.53). The difference in Action as against the commonality of professed belief was significant at the $p < .025$ level ($t = 2.37$, $df = 20$).

The Holistic Elementistic subscale significantly separated A (Holistic) from B (Elementistic) at the $p < .05$ level ($t = 2.0$ $df = 20$).

B tends to categorize things more than A at the $p < .025$ significance level ($t = 2.3$, $df = 20$).

The Subjective-Objective, Dynamic-Static, and Deterministic-Voluntaristic subscales while generating responses in the expected direction (Dept. A - Dynamic, Voluntaristic and Subjective) did not reach a level of significance.

The profile of OM scores for the department revealed that some members of Dept. A had scores closer to the tough-minded end of the continuum than some members of Dept. B. These particular people are into computer simulation and mathematics more than their compatriots while those members in Dept. B with scores closer to the Tender-minded end of the continuum turn out to be social scientists.

Discussion

The significantly different scores obtained by Dept. A and Dept. B on the OM Scale supported the hypothesis that these two groups tend to perceive and explain the world from different points of view. This might underlie a propensity for each group to make different policy decisions. For example, the difference in the two department's scores on the Educational Policy subscale mirrors an actual difference in policy. Dept. A had a more open-ended individually oriented learning approach while Dept. B was more structured with general requirements and a heavier emphasis on exams and rigor.

The most interesting result of this study was the curious directionality of each department between the Action and Belief subscales of the OM Scale. If these two groups are actually saying that they believe one thing and then turning around and doing something else, the level of mutual trust would be expected to fall. This might then be another source of conflict for the School. Since Dept. A said that they believed more toward the Tough side (in relationship to their own scores) while saying that they would act more toward the Tender side, and Dept. B said they believed (in relationship to their own scores) more toward the Tender side and would act more toward the Tough side. Another factor associated with the dichotomy in cognitive persuasions may have been revealed. Tough-minded views have for a considerable time been the reigning ethos in high level policy-making places. The scientific world view has commanded the most grants and the highest accolades. Tender minds have constituted a veritable counter-culture. It could be then that Tender minds might publicly support reigning values as long as they did not have to do something about it. On the other hand, the Tender minds may have values that are considered desirable as personal attributes, which may lead more Tough-minded people to espouse these values. A viable community thrives on the anti-entropic forces exercised by diversity. It seems reasonable to accept the fact that both Tough and Tender minds are necessary to the creation of such a community. In fact, they might be considered the two sides of the same coin. The problem to be considered is the fostering of their acceptance and celebration of each other with the possible added benefit of personal cognitive expansion.

Summary

An investigation into the source of communication difficulties between two associated groups of environmental experts revealed that the two groups view the world from different points of view.

It was suggested that while this difference can create problems, its inherent diversity provides an anti-entropic force for community viability and personal growth.

Conclusion

Most of us would agree that there is only one phenomenal world. It also appears as though Tough and Tender minds see that world from opposite points of view. If we combine both these viewpoints we may get a more complete approximation of the world.

	World	
Objective (priority placed on thing that is seen		Subjective (priority placed on the way a thing is seen)
Facts	Meaning of World	Values
Outside Self		Inside Self
External Determinism spectator knowledge emphasis on getting and evaluating facts	Get it Together and do Something With it	Internal Determinism participating knowledge emphasis on creativity

If, however, people operate from only one point of view, their assumptions about the world may turn out to be presumptious. An environmental policy maker makes public decisions that last long into the future and affect the lives of people who may be of the opposite cognitive persuasion. It would be as if a Tough-minded educator instituted a highly structured programmed-learning curriculum and a group of Tender-minded, subjectively propelled kids would have to go through it, or a Tender-minded educator created an open program where everyone could do as they pleased and the students who preferred more structure came begging for direction.

Although no hard evidence has as yet been gathered, it is possible that cognitive persuasions with their associated value systems make up a significant part of what might appear on the surface to be a simple design decision. In other words, the way you view the world contains covert assumptions about the nature of people. These assumptions may lead to decisions about the physical world that you help design for those people. One dimension of the design decision process is, for example, where do you put the locus of control? Do you put it inside the citizen and consider that he will, for example, maintain the public housing project you are designing and he will occupy. Your design would be such that a private citizen could actually maintain his own premises and special equipment would not be needed. If, on the other hand, you place the locus of control outside the citizen, then you will design a building for a hired maintenance system. Do you want a world that citizens maintain, or that is professionally maintained? You choose the kind of world we have by the decisions you make. Those decisions are based on your view of the world and the people in that world. Rosenthal and Jacobson (1968) showed us that if you view a child as smart, his tested IQ rises. In other words, you get what you expect. We may be getting what we "covertly" expect. Making these expectations overtly manifest may lead us to change our point of view, even our world view and possibly expand our cognitive persuasions to take in both points of view.

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THE TRANSITION TO SYSTEMS ARCHITECTURE

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Introduction

Shelter from the elements is basic to human existence. But, in our modern world, it is more than a bare necessity. The quality of shelter affects the quality of life, as well as the physical environment, and reflects the condition of society (Fig. 1). It is to that present condition that we must address ourselves.

Within the last century, our technological progress has been greatly accelerated. Concurrently we have experienced new and more difficult problems - partly as a result of increased population; and equally as a result of our new technology. Industrialization and new discoveries have given rise to larger urban complexes, suburban development, increased product output and many specialized services to meet changing demands. The result is an over abundance of goods and services, each capable of - yet limited to - fulfilling specific requirements. The rapid proliferation of these "tools" has brought us an uncoordinated accumulation of fragmented efforts - some succeeding in a limited way, all of them in periodic conflict, and none of them realizing their combined potential.

If the construction industry is to successfully fulfill its role of providing every human being with adequate shelter, and thus elevating the structure of our entire society, it must develop the expertise required to utilize all available tools in a logical and organized way. A total methodology must evolve

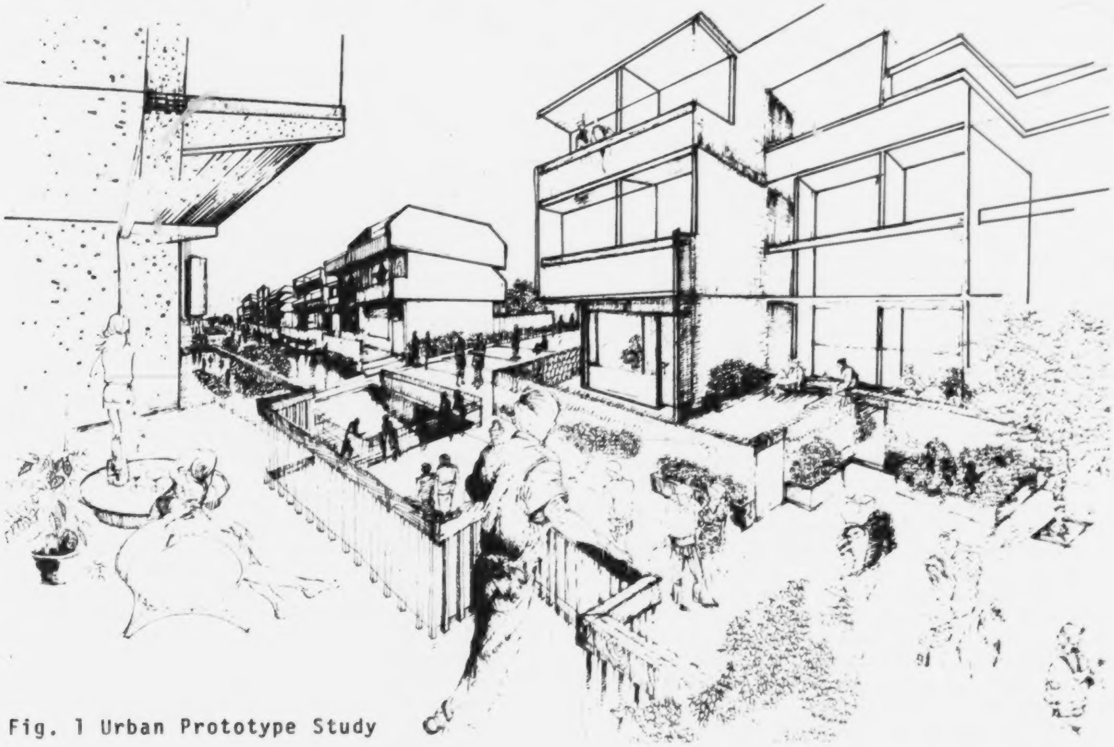


Fig. 1 Urban Prototype Study

which will respond to an ever changing program, and serve as a coordinating catalyst for the optimum interface of all "software" services and "hardware" components. The architect of this systematic approach will create his position as "master builder of the twentieth century". The task will not be given to anyone, but, the challenge is there for anyone to accept. Inroads are being made and new leadership is emerging, but many obstacles still present themselves. Vested interests and traditional practices must give way to social conscience and rational solutions. Those who assume leadership must also accept the responsibility of championing these ideals. However, a basic understanding of related factors must be achieved by all concerned, if a coordinated team effort is to evolve which will permit us to solve the many complex and interelated problems.

It was to that end, that in October 1968, a decision was reached to develop The Total Building System. The concept behind this decision was to provide in one corporate structure, all the capabilities of construction management, techniques and components that constitute any project undertaking, and make them available to the construction industry.

The Problem

In terms of present and future massive demand for space, construction undertakings will be more sizeable, and will not be handled in the traditional manner. To date, construction has been carried on as unrelated individual projects. A simple triangular relationship between client, architect and general contractor has served the industry for generations. Success of the undertaking was determined by the talents of these few people.

In the past century, a dramatic increase in population, factory mass production techniques, increased communications and advertising media, improved methods of transportation and the evolution of a large middle class society has led to a different team. Basic relationships have remained unchanged but the membership has increased, and the involvement of each has become more interelated and sophisticated. How then can a better system emerge which will achieve the methodology envisioned? A review of one attempt may offer possible solutions.

History of Omniform - The Corporation

Research and discussions led to formation of Omniform Incorporated in 1969. Its officers and directors consisted of principals from architectural, legal and engineering firms, and in addition, a bank official and a businessman. Initially four additional corporations were contemplated, as subsidiaries of the parent company.

An Environmental corporation to offer a complete range of environmental planning services to sponsors, franchisees, neighborhood groups and all levels of government. Services would include urban renewal, community planning and economic feasibility studies, site selection, complete building design and engineering and sociological surveys. Expert consultation would be provided in the use of all subsystems, and comparative cost data could be furnished for a variety of project types. Technical data and visual aids would be furnished, including engineering manuals, specifications, models and photography services. Local professionals would be assisted, or supplemented with those services as may be required for a particular project. Research and development of new techniques would be a continuing endeavor.

A Building Systems corporation to hold the master franchise and license for the total system, and make it available throughout the country. Testing facilities for continuous research and refinement of hardware assembly and erection techniques would be maintained. A center would be established for personnel of licensees and franchisees that require training in management, operation or construction of the system. In addition, the staff of this division would program job opportunities for minority groups and train local labor forces for the on-site assembly of building components, as well as manufacturing procedures.

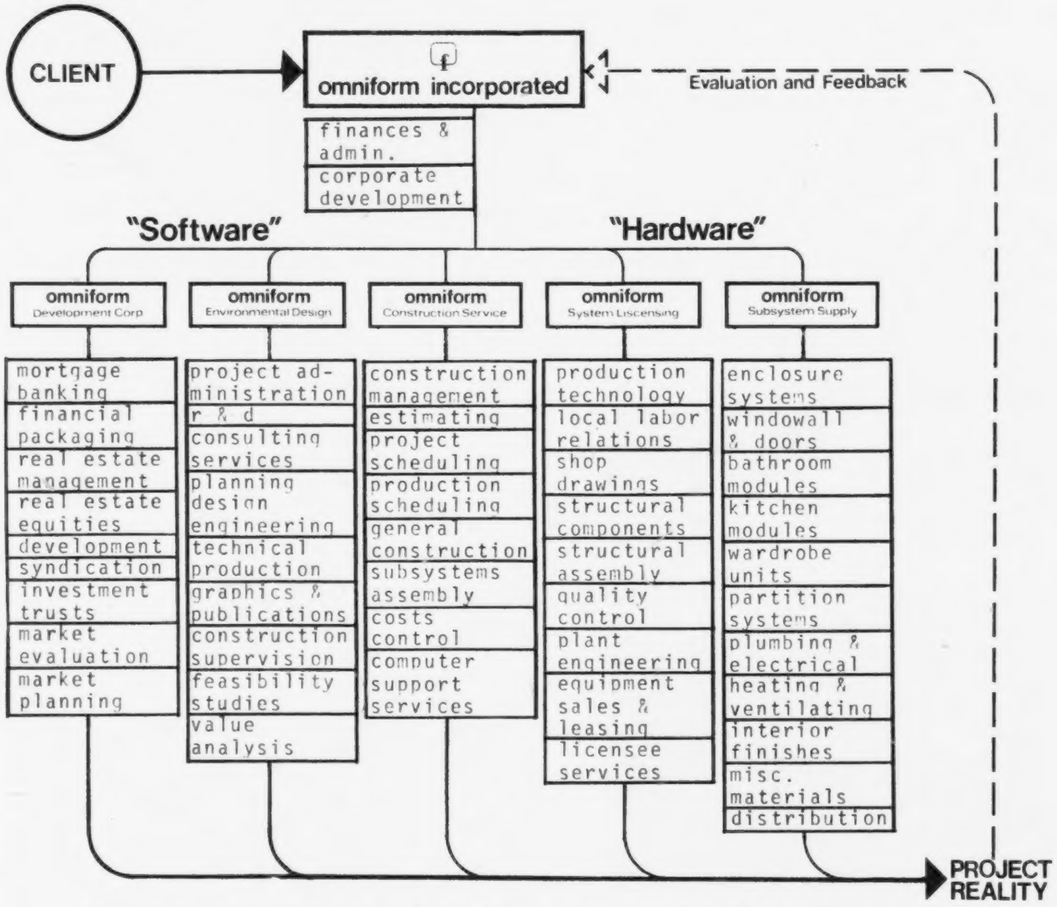
A Computer Data Center, to systematically preplan, organize and tightly schedule and coordinate project phases and construction sequence. Daily construction time reports would be processed, and work assignments updated in order to maintain schedules and assure the most efficient use of manpower. In addition, the computer center's information storage and retrieval system could, collate component interface data to continually increase the system's variety of planning arrangement and uses. Remote terminals to the nationwide computer network would be installed at the franchisees' headquarters on a timesharing plan basis.

A Building Supply corporation was conceived to handle central purchasing and operate regional distribution centers for the supply of all components in the total system, since transportation is a major economic factor related to component supply. By establishing a nationwide program, volume purchasing power could be passed on to the local sponsor in reduced component cost, and standards of quality could be controlled. If desired, this division could also supply manufacturing equipment to local licensees.

At present, the corporate structure has altered slightly, but basic concepts have remained (Fig. 2). One new important subsidiary has been added - a Development corporation. Assuming all members of the team are committed to its collective success, the system will work. With human nature being what it is, however, that is a big assumption, and the association is still in the process of change.

History of Omniform - Hardware

Much had already been accomplished in Europe using systems techniques; and in America, many promising attempts were being made. What was needed was a coordinating effort, not another conflicting attempt. The goal was set - to research and select the best of what was presently available, and work together to


CLIENT
omniform incorporated
Evaluation and Feedback
finances & admin.
corporate development
"Software"
"Hardware"
omniform Development Corp
omniform Environmental Design
omniform Construction Service
omniform System Liscensing
omniform Subsystem Supply
mortgage banking
financial packaging
real estate management
real estate equities
development
syndication
investment trusts
market evaluation
market planning
project administration
r & d
consulting services
planning design engineering
technical production
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construction supervision
feasibility studies
value analysis
construction management
estimating
project scheduling
production scheduling
general construction
subsystems assembly
costs control
computer support services
production technology
local labor relations
shop drawings
structural components
structural assembly
quality control
plant engineering
equipment sales & leasing
licensee services
enclosure systems
windowall & doors
bathroom modules
kitchen modules
wardrobe units
partition systems
plumbing & electrical
heating & ventilating
interior finishes
misc. materials
distribution
PROJECT REALITY

Fig. 2 Present Corporate Structure - The Total Building System

adapt, modify and integrate all elements within the discipline of the total building system. It was decided to concentrate on those techniques applicable to large scale urban complexes. Lesser systems, limited to scattered suburban use, were viewed as an unacceptable solution to the shelter crisis, and would do little to alleviate the suffering of the cities and the destruction of the countryside.

Of central importance to the "hardware" package was a primary structural system. Preliminary research indicated that it constituted approximately thirty percent of the building cost. In addition, it established the framework within which all other components must be interfaced. Again, research into what had been done pointed the way. Our findings generally concurred with those of Sepp Firnkas Engineering, Inc., pioneering innovators of precast concrete systems construction (1):

1. Industrialization offered many advantages - year round employment and job training opportunities, increased production efficiency, quality and reduced labor costs are but a few.

2. Although European systems had marked advantages over conventional construction, U.S. codes and practices in planning, construction, labor, administration and financing made adaption difficult and costly.

3. Closed systems are extremely inflexible; open systems allow creative solutions to a great variety of program requirements (2).

4. More than one system is necessary to satisfy the great variety of building types and uses.

Based on his findings, and subsequent efforts, Mr. Firnkas had developed a structural system meeting U. S. criteria, and had successfully utilized it on over 3,000 housing units. This open, fully industrialized structural subsystem (Fig. 3) became the nucleus of Omniform's "hardware product" in 1969, and has served as a basis for continued research and development of additional subsystems (Fig. 4).

Manufacturers had begun to produce prototype components related to systems building. Complete bathrooms, kitchens, etc., were appearing on the market. However, as individual products, they offered little hope for solving the overall problem. Each was attempting to be different for "sales appeal", and contributed to the already confusing array of building products and assembly techniques. Discussions were held with hundreds of manufacturers in an effort to find companies whose components would be compatible within the parameters of the system. Basic criteria for selection included:

1. A readily marketable product offering design flexibility, econo-

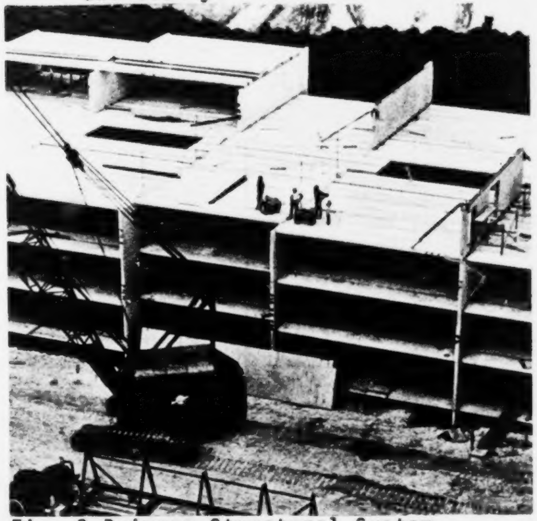

Fig. 3 Primary Structural System
Engineer: Sepp Firnkas

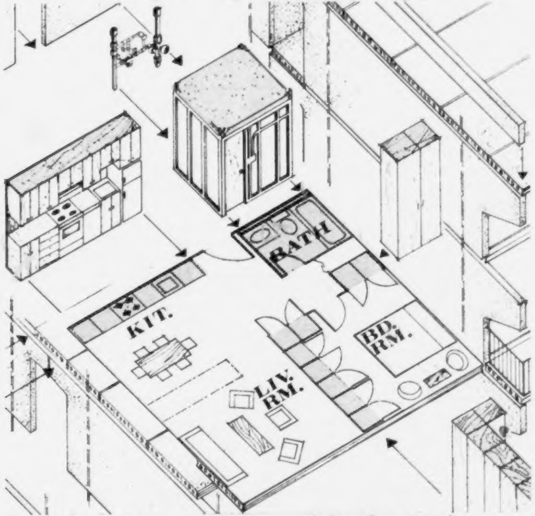

Fig. 4 Subsystems Assembly Concept
Arch: M. N. Crabtree Assoc., Inc.

my, quality and more efficient use of labor.

2. A potentially acceptable product. and the willingness to develop it within our established standards.
3. A committment to jointly research and develop interface procedures with Omniform and with other companies involved (3).
4. Establishment of a national account, offering volume purchasing power immediately.

At this time, sixteen independent manufacturers are producing fully integrated precoordinated subsystem components for use within the Omniform system. Included are enclosure systems, bathroom and kitchen modules, wardrobe units, windowall and door assemblies, partitions, mechanical, electrical and plumbing systems, and interior finishes (Figs. 5, 6, 7, and 8). Products from other manufacturers come under the continuing evaluation of a research and development program, and once tested and approved they will be added to the system.

History of Omniform - Software

Concurrent with the development of hardware components, was the refinement and application of software techniques and services. The concept of "team effort" had to be made acceptable. Fortunately, others believed the same thing. Developers, architects, builders, and financial consultants were beginning to work together on projects - pooling their efforts, avoiding costly mistakes and eliminating time consuming duplication of services. We had to make our techniques available to this group for immediate application, while continuing to expand our own in-house capabilities.

A licensing and franchising program was begun. Since the structural system had been developed for the American market, existing precast plants could easily produce it with minimal additions to their equipment, making initial investment low. Any new operation also required a relatively low investment, due to the simplicity of the system and the advanced precasting equipment (Fig. 9) available through the parent company (4). Several Eastern states now have the system available to them (5). This decentralization was extremely important for several reasons:

1. A plant producing the precast system can only service an area of approximately 400 miles in diameter, due to the economics of delivering components which weigh up to 25 tons. Licensing would expand its geographical availability.
2. A potentially large market had to be aggregated to solicit the participation of manufacturers.

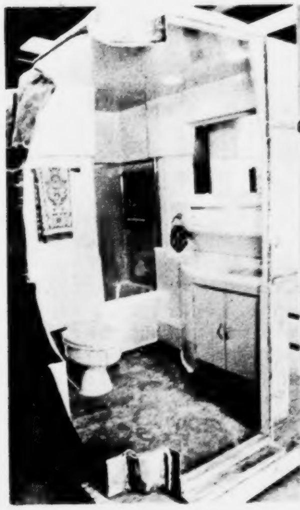

Fig. 5 Bath Module

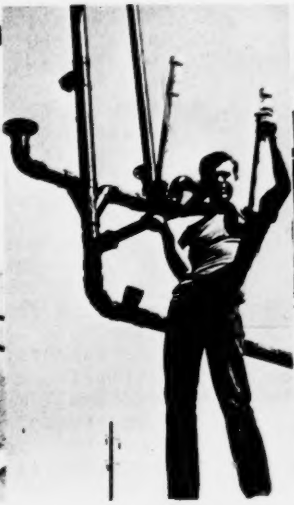

Fig. 6 Plumbing Tree

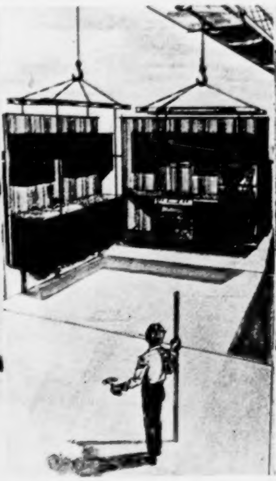

Fig. 7 Kitchen Walls

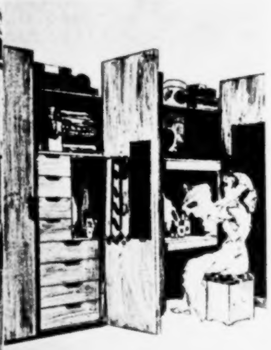

Fig. 8 Wardrobe Units

Typical Subsystems by various manufacturers for precoordinated interface within the System

3. Construction of a new facility in our local area would have been time consuming; licensing would make the system available immediately and free us to continue research and development.

4. Each group would bring new personnel and additional expertise to the team.

Once the licensing program was successfully underway, new problems began to present themselves. Many additional services were required which an architectural firm does not normally offer. A complete graphics department was established for the publication and dissemination of information to licensees and their potential clients. Exhibits were designed and sent to conferences and shows. Coordination of information and partial displays from many subsystems became important, in order to demonstrate the concept of full integration.

Cost and performance analysis of each new subsystem was evaluated and programmed into each request for a budget estimate. Licensees requested assistance in production techniques; manufacturers wanted to sell the products they had put time and money into developing; and clients demanded services involving financial assistance, job training programs, ecological studies, general contracting, a guaranteed "turnkey" price, etc.

Personnel was added to a conventional staff of architecturally trained project captains, designers and draftsmen. Additions included housing consultants, legal and financial advisor, precast expert, graphic artist, cost estimator, and an administrative coordinator. In order to direct these diverse activities, principals of the architectural firm assumed specialized areas of involvement - corporate management and finances, environmental design and project management, subsystems research and development, and systems design - and began to function as a team.

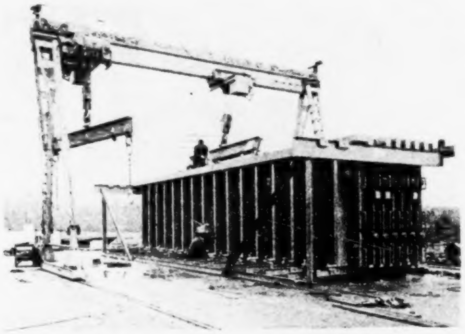

Fig. 9 42' 6-cell Vertical Battery Casting Machine by Stelmo

During the first two years of transition, over sixty projects were submitted for review and possible application of the system. Complete teams were formed to submit proposals on a turnkey basis. Joint venture associations were established to bid on projects utilizing performance specifications. Feasibility studies were performed. Conferences were held with interested groups or individuals to explain what had been accomplished with part of the system (Figs. 10 and 11), and the value of new applications to suit the specific needs. Prototypes were developed indicating what could be accomplished at various cost levels (Figs. 1 and 14). Technical manuals and catalogs were assembled to illustrate the components and interface procedures specific to the use of the system.

If economic success is the criteria, the system has not yet fulfilled its expectations. To date, only one project is under construction. However, partial successes have lent encouragement to continuing the effort:

1. During the first few months of Omniform's existence, "Operation Breakthrough" was announced. Two hundred and forty-four type A proposals for a total system were submitted. Omniform was one of thirty-seven selected. Unfortunately, it was eliminated during final contract offerings to twenty-two companies.

2. Omniform was one of nine systems from throughout the country qualified for use on a housing project proposed for the Department of the Navy (6). Working with general contractors who had to submit bids utilizing one of the preselected systems, Omniform was included in the presentation of the two low bidders. The project did not materialize due to insufficient funds.

3. A complete team was assembled and worked together to produce a fea-

sibility study including design, outline specifications, CPM, guaranteed project cost (almost 10 percent below average market conditions for the area) fast track schedule, and marketing and rental procedures in less than one month. The client has not yet decided to proceed, and the 13 million dollar commercial project has been shelved. Several other attempts, with similar results, proved that a workable systems team has been assembled (Fig. 12)

Conclusions and Observations

Feed back and self-evaluation have led to certain realizations concerning our limited success. According to government reports, the construction industry is the largest in the country, representing approximately 10 percent of the gross national product (7). Unfortunately, antiquated codes, union practices, segregated markets, professional societies, non-professional associations, etc., make it one of the most fragmented and least progressive. Its size alone causes enumerable problems, and has obviously contributed to the difficulties encountered by all systems companies. Stable continuous production and volume are necessary to reduce component costs. In today's economy, this stability is virtually non-existant. Therefore, a systems producer must seek to develop projects and insure a constant market for his product.

Many design professionals are reluctant to become involved with systems, citing loss of creative freedom and sterility through standardization as their objections. What is lacking is the realization that hardware components, economics and politics have been dictating design for years, and will do so to a much greater degree in the future. If a meaningful design contribution is to be made, it must work within the parameters of production capability, delivery procedures, assembly techniques, economics and other related disciplines.

Complete familiarity with a system's capability is necessary if it is to be applied successfully. As with all tools, limitations must be understood and acknowledged. Failure to do so will offset any potential gains. Systems is new to American industry, and its proponents have not yet tested many of their theories, making users extremely cautious.

Too much emphasis is being placed on building systems (the product), and people have been led to believe that buildings would soon be rolling off the assembly lines at greatly reduced costs. This is simply not true, and confidence has been lost. Our research indicates that hardware, at best saves only a few percent of the total building cost. Rather, systems building (the process by which a project evolves from conception to physical reality) is the key.

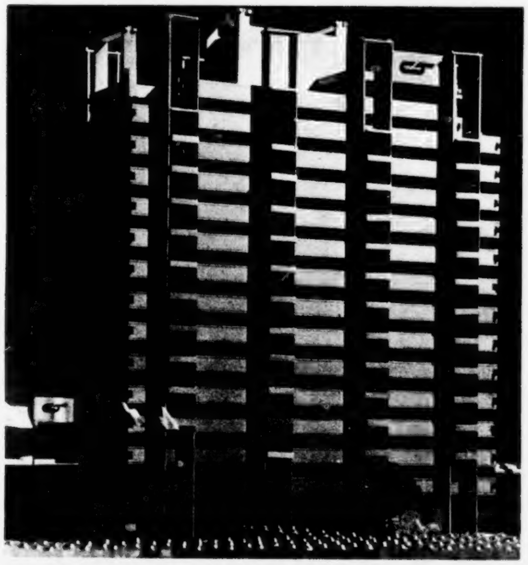

Fig. 10 Brookhollow Plaza One, Texas
Arch: Paul Rudolph

Fig. 11 North Harvard Housing, Mass.
Arch: PARD Team

Too much is being expected too soon, and companies are spreading their abilities too thin in an effort to offer complete one source responsibility. It is unlikely that this goal will ever be achieved. There are too many conflicting interests involved to allow single responsibility to become acceptable, or even desirable. Architects should not be held responsible for the actions of a general contractor; and, contractors should not be accountable for the failings of manufacturers or craftsmen. Yet many laws make these inequities a fact of life in the construction industry, and it is the client/user that suffers. This must change.

Finally, self-interest and the profit motive govern our society. Until union practices become socially responsible (8), negative zoning and restrictive codes are corrected, business and government agencies place moral value at least equal to dollar value, and architecture and environmental design are not considered expensive "frills", coordinating the efforts of the construction industry will be a long uphill struggle. Real pressure to develop systems does not yet exist in America as it did in Europe after the devestation caused by war. Hopefully, we will not wait for a similar disaster.

The Future

Greater individual responsibility will be required in the future, coupled with an equal committment to the collaborative effort. Each member of the building team must be accountable for his input, and a system of checks and balances must be maintained to insure the potential success of every project undertaking. By success, we must include architectural and social value in addition to merely completing the building on time, within the budget and at a profit to those involved. Relating this criteria to the single source, total building system concept we find a direct conflict between the motivations of professional software service groups and the profit oriented hardware divisions. Both are fully justified and necessary. However, their positions are weakened by inter-dependence within one economic structure. Critical to the situation is the loss of professional objectivity.

It is inevitable that corporations of this type will have a major effect on the future of our environment. Design professionals who become part of this team must make every effort to involve themselves in the intricate workings of the total system, and become leaders at the management level, if they expect to exert any influence on major environmental decisions.

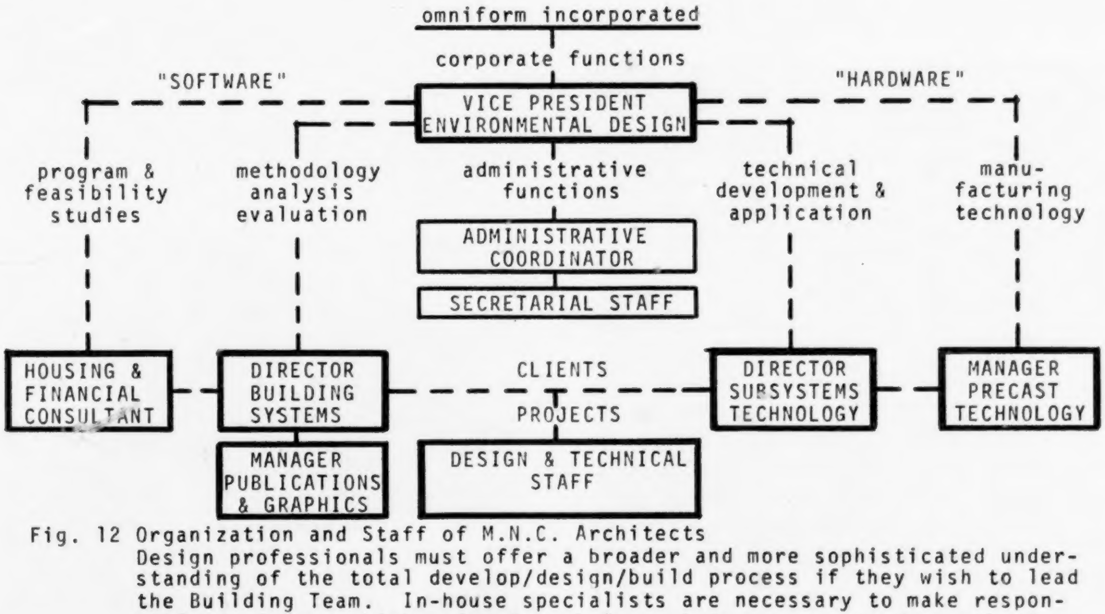
omniform incorporated
corporate functions
"SOFTWARE"
"HARDWARE"
VICE PRESIDENT ENVIRONMENTAL DESIGN
program & feasibility studies
methodology analysis evaluation
administrative functions
technical development & application
manufacturing technology
ADMINISTRATIVE COORDINATOR
SECRETARIAL STAFF
HOUSING & FINANCIAL CONSULTANT
DIRECTOR BUILDING SYSTEMS
CLIENTS
PROJECTS
DIRECTOR SUBSYSTEMS TECHNOLOGY
MANAGER PRECAST TECHNOLOGY
MANAGER PUBLICATIONS & GRAPHICS
DESIGN & TECHNICAL STAFF

Fig. 12 Organization and Staff of M.N.C. Architects
Design professionals must offer a broader and more sophisticated understanding of the total develop/design/build process if they wish to lead the Building Team. In-house specialists are necessary to make responsible decisions which maintain a balance between user-need, aesthetics, practical capability and economics.

Alternatives are presenting themselves, and we are proceeding in their direction. Transitional problems have often required personnel to wear many hats, alternately assuming responsibility in opposing areas. The educational process has been enlightening and has contributed to a broad understanding and respect for other disciplines. However, theoretical separation of software and hardware has survived and is again becoming a reality.

Two important vocations are emerging during the evolution of systems in this country - The Building Team Coordinator and the Construction Manager. Qualifications for each position are being debated throughout the industry. Claims to the titles are heard from all sectors. Gradually the positions will be assumed by those capable of fulfilling the requirements and the structure of the building team will have two leaders (Fig. 13). In function, this team will parallel the procedures required within the total in-house system; in practice, it will automatically insure adequate checks and balances. It is open and flexible, and can be specifically tailored to fit the program; the other is closed, and will become an industry unto itself - not a technique.

It is important to note that the leaders of this team must be familiar with the forces at work within it. Equally important, they must personally seek to develop and implement this knowledge (there are few case histories, textbooks or qualified instructors yet available to guide those interested).

Who should be interested? Each response must be personal, however, it is curious to note that the upper portion of the new team is identical to the simple triangular structure we have used for years. Although the names have changed to suit the times, perhaps the traditional roles have not - except through evolution and expansion to a more demanding and sophisticated level.

There is no magic to systems - it is simply a logical approach to solving problems. Today our problems are more complex and require the input of many additional people. The transition to systems architecture entails individual responsibility and a team committment. The successful large scale projects of the future will have many authors.

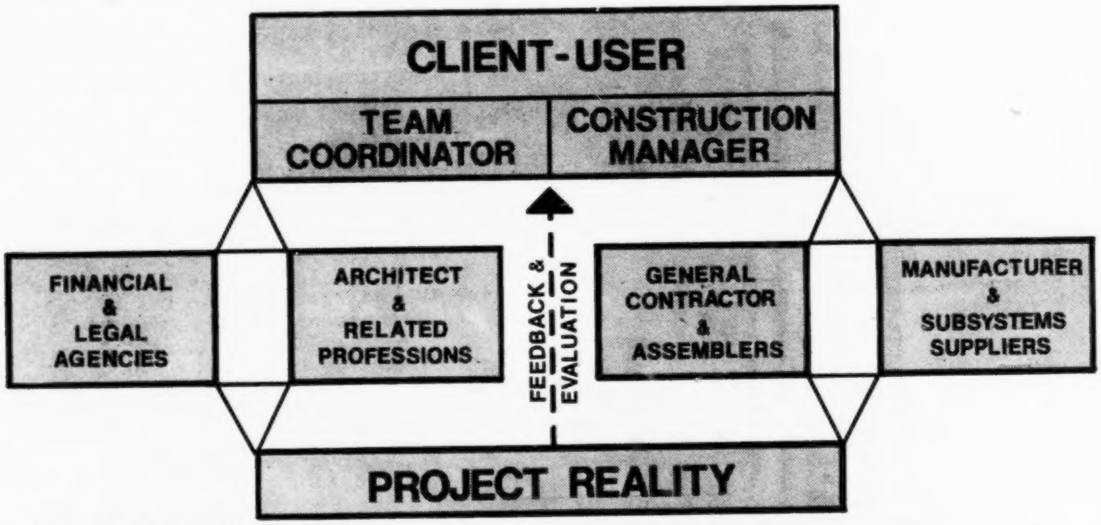
CLIENT-USER
TEAM COORDINATOR
CONSTRUCTION MANAGER
FINANCIAL & LEGAL AGENCIES
ARCHITECT & RELATED PROFESSIONS
FEEDBACK & EVALUATION
GENERAL CONTRACTOR & ASSEMBLERS
MANUFACTURER & SUBSYSTEMS SUPPLIERS
PROJECT REALITY

Fig. 13 The Building Team
Two new professional leaders are emerging. The Team Coordinator must input a creative talent, the Construction Manager must offer realistic guidelines. Together, they will administer the total project, evaluate alternative data, and base selection and implementation on the optimum interface of all related factors.

NOTES

(1) A research paper pertaining to these findings was prepared by Sepp Firnkas, titled "A U.S. Building System: An Experience and Lessons to be Learned". It was published in the Proceedings of the International Symposium on Low Cost Housing Problems Related to Urban Renewal and Development, October 8, 9, 1970, Civil Engineering Department, University of Missouri - Rolla.

(2) An open system is compatible with a number of interchangeable components from related systems or from coordinated supply sources. In addition, an open system allows the use of conventional construction materials and methods together with the components of the system.
A closed system is ordinarily not compatible with other systems, nor with conventional construction methods. It does not permit deviations from standard plans associated with the system. This reduces flexibility considerably.

(3) Many coordination meetings were held. If parts are not designed and manufactured to interface with each other, subsystems will be useless.

(4) Steel formwork specialists have developed a range of equipment for the industrialized building industry throughout Europe. Concrete production equipment designed specifically for the Omniform System followed a combined research and development program carried out jointly, and in depth, by the two organizations.

(5) The complexity of licensing and franchising transactions is not to be minimized. This is easily understood when one realizes that potentially millions of dollars are involved. Resistance is strong, since precasters are busy producing architectural "decorative" concrete, and have little economic need to become involved in structural systems. This paper will not attempt to deal with business and legal activities required. It is sufficient to note that the program could not have been successful without the involvement of a large financial institution, legal consultants, precast experts and a public relations firm, in addition to the architects and engineers of the system.

(6) Building Systems Development, Inc., was retained by the Department of the Navy to review, evaluate and select systems prior to bidding the project. Only those prequalified could submit bids based on the performance, drawings and specifications prepared by BSD.

(7) Many conventions, conferences and exhibitions were attended during the development of Omniform. Statistics were consistently presented by qualified experts calling for the reorganization and better management of the construction industry.

(8) Perhaps a national systems union should be developed to replace the precedents and restrictions set by outdated methods of construction.

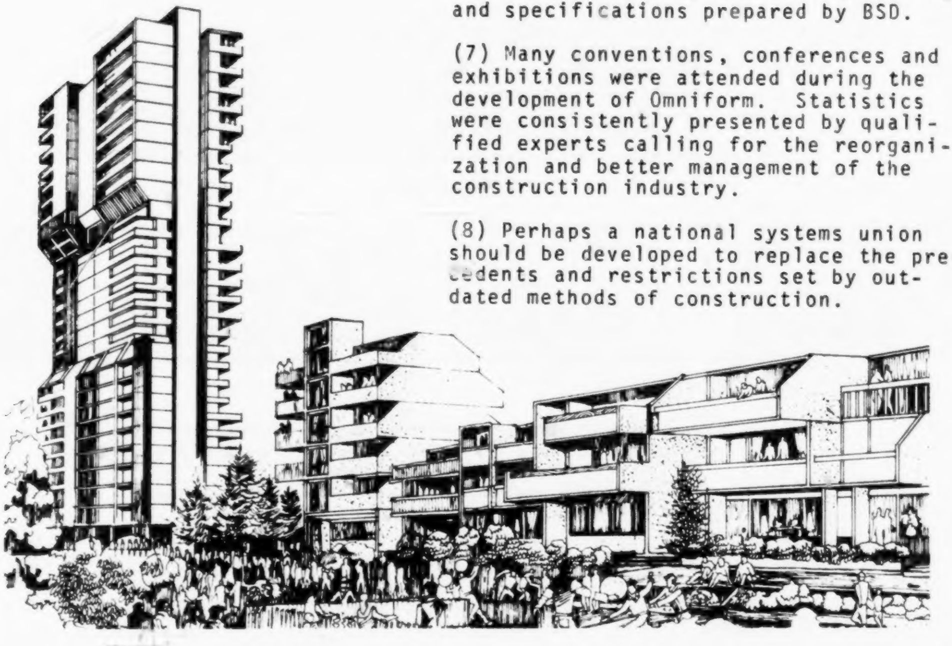

Fig. 14
Urban
Prototype
Study

18: STRATEGIES FOR RESPONSIVENESS AND ACCOUNTABILITY

COMMUNITY DESIGN CENTERS AND THE ENVIRONMENTAL PROTECTION ACT OF 1969

David Angelo
Raul Escobedo
Alexander M. Man
Xavier Mendoza
Manuel Orozco
Frank Villalobos

Barrio Planners, Inc.
Los Angeles, California

The A.I.A. has been an effective force at the Federal level in the legislative advancement of several Federally funded programs related to land use, housing, new community special planning, comprehensive planning, urban mass transportation and the Environmental Policy Act of 1969. A.I.A. also lobbied actively in support of Model Cities legislation in 1966. Currently A.I.A. is actively supporting legislation to establish Community Design Centers under Senate Bill 2007.

Frequently the effects of the Federal grants that have resulted from A.I.A. supported legislation are barely visible, so inept, sluggish and complex is the machinery of Federal, state and local government in the actual implementation of the grant programs.

To develop credibility, visible results must also be achieved. One does not achieve either if the city and country dwellers affected by the programs do not participate in the decision making process usually called for in the administrative guidelines of the Federal programs.

The intent of Congress in passing a variety of legislation related to housing, land use, transportation and environmental impact law has frequently been ignored by the agencies administering the programs. Many of us despair as wasted time and money destroys the hopes of citizens groups as to the responsiveness of government to the needs of people who are supposed to benefit from the federal legislation.

In the East Los Angeles HOME PROGRAM, (funded in 1968 by the Department of Housing and Urban Development) Urban Beautification Program funds are being used by Los Angeles County agencies to remove 2500 mature street trees (6" - 18" diameter). Los Angeles County has applied to H.U.D. for a new grant to run through 1974, in order to continue the HOME PROGRAM.

Prior to the passage of the Environmental Protection Act of 1969, (Public Law 91-190) practically no legal or administrative means existed to halt destructive activities involving the misapplication of Federal funds by local government.

Barrio Planners have notified H.U.D.'s Southern California Environmental Clearance Officer that we believe the County application for HOME PROGRAM funding should be rejected until the County has submitted a satisfactory Environmental Policy Statement to the Department of Housing and Urban Development and the Environmental Protection Agency.

This is the second attempt by the Barrio Planners Community Design Center to utilize the Environmental Protection Act as a Design Center tool for correcting state and local agency misuse of Federal funds in a manner that frequently violates the intent of Congress and is contrary to public interest. Our first attempt to use the Environmental Protection Act was made in July, 1971, when the Department of Transportation and the Environmental Protection Agency received the Barrio Planners independent environmental statement regarding the proposed Busway on the San Bernardino Freeway.

How effectively Community Design Centers and other Federally subsidized programs can be tied into a more potent use of the Environmental Protection Act and the favorable court decisions that have come from that law will be determined by concerned citizens, affected community groups and the work done by Community Design Centers in an attempt to preserve and improve the cities and countryside of America.

In February, 1971 the Barrio Planners received a "Draft Environmental Statement" prepared by the California Division of Highways and the Southern California Rapid Transit District. The application of the two agencies for a Federal Highway Administration subsidy to build a Busway on the San Bernardino Freeway required that they submit an "Environmental Statement" to the public and the interested Federal agencies.

Because of the voluntary nature of our design center and the limited time available before a position statement could be prepared, we decided to concentrate our evaluation on the section of Busway between the U.S.C. Medical Center Busway station and the State College Busway station. Our most immediate concern was the section of the proposed Busway that would be adjacent to Romona Gardens Vest Pocket Park that we had designed. A member of the Barrio Planners testified at a public hearing called on March 2, 1971 by the State Department of Public Works and the Southern California Rapid Transit District.

The remarks of the Barrio Planner representative were directed mainly to the "Draft Environmental Statement" of the two agencies, and the failure of their statement to consider the potential noise level from the Busway and activated Railroad Track. He pointed out the need for a high concrete wall to protect the vest pocket park from Busway, Freeway and Railroad noise. Additionally the spokesman criticized the "Draft Statement" for its failure to consider landscaping the San Bernardino Freeway corridor to visually screen out Busway, Railway and Freeway activities between Soto Street and State College Station. He concluded his statement to the hearing by observing that the first paragraph on page 11 of the "Draft Statement" reads ".....Scenic values are considered to remain UNCHANGED because of the present urban development, wildlife habitat are not known to be affected, nor are any streams having fish resources involved." Plainly the intent of the agencies applying for the Busway grant is not to upgrade or correct the existing barren condition of the San Bernardino Freeway corridor, which is an environmental disaster area because of the past failure of the Highway Department to take even modest landscape screening measures along the Freeway.

Approximately 1000 people attended the March 2, hearing in San Gabriel, however, ours was the only testimony given regarding the noise and landscaping elements of the Busway proposal. The concerns of the other opponents centered around the displacement of homes for Busway parking lots and the generation of local traffic on residential streets adjacent to Busway stations.

In the interval between the public hearing and the publication of the "Final Environmental Statement" the Barrio Planners carried their investigation into the effects of the Busway much further, and were better able to evaluate the data, observations and conclusions of the "Final Statement".

It was apparent that, aside from the minor conclusions made on the sound abatement wall, (a six foot high wall for 16 foot high locomotives) at the Ramona Gardens Vest Pocket Park and the elimination of the Busway mid-point parking lot at San Gabriel, the Division of Highways, the Southern California Rapid Transit District and the concerned Federal agencies whose remarks were attached to the "Final Statement", were still ignoring the intent and legal requirements of Public Law 91-190.

The Environmental Protection Act emphasizes several areas that the interested Federal agencies (Environmental Protection Agency and the Department of Transportation) are required to consider in the enforcement of the Act. Among them are: (1) The environmental impact of the proposed action. (2) Any adverse environmental effects which cannot be avoided should the project be implemented. (3) Alternatives to the proposed action. (4) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long term productivity. (5) Any irreversible and irretrievable commitments of resources which would be involved if the proposed action should be implemented. (6) Study, develop and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources. (7) Make available to states, counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining and enhancing the quality of the environment.

Very little of the legislative intent of Congress outlined above was incorporated into the thrust of the "Final Statement" of the two agencies applying for the Federal Busway grant. The comments of the "concerned" Federal agencies which are attached to the Appendix, show a similiar indifference to the duties assigned them by action of Congress and Presidential Executive Orders.

After considering the serious deficiencies of the "Final Environmental Statement", the Barrio Planners decided to rebut the "Final Statement" with an independent environmental statement of their own.

As a Community Design Center we had been planning to do a general study of East Los Angeles Environmental conditions. Our Busway environmental report became the first step in the implementation of our East Los Angeles Regional Study, necessary for the ultimate development of an area master plan. Individual members of the Barrio Planners had been collecting much social, economic, noise, educational and pictorial data over many months, much of which was relevant to factual backup needed in an independent environmental statement. We decided to expand the range of our factual materials and environmental concerns to include the San Bernardino Freeway corridor from Medical Center Station to California State College.

Because we all have regular jobs, tasks were divided up according to available time, interest and abilities. The serious difficulties of an unsubsidized Community Design Center suddenly became apparent to us as we advanced large sums of money out of pocket to meet the costs of producing 100 copies of "Impact on Impact".

Up to the time we decided to do an independent study, the Division of Highways had been most cooperative, offering us right-of-way maps and Busway plans as we needed them for our vest pocket park design work. Suddenly we were asked to pay for materials we needed to define the environmental and noise pollution boundries and effects of the Busway and activated railroad track on adjacent residential areas and local elementary schools.

Because of the pending Busway condemnation proceedings against the Southern Pacific right-of-way, the railroad and the two agencies applying for the Federal Highway Administration grant had been holding meetings regarding the use of Busway Federal funds for the construction of thousands of linear feet of railway retaining walls between Soto Street and State College and a $2,900,000 railway trestle next to an El Monte municipal park. We asked to attend the right-of-way capital improvement meetings but were told "it was a private matter".

Noise readings on the San Bernardino Freeway corridor and on the five other East Los Angeles freeways had been gathered for the Barrio Planners in cooperation with California State College (Department of Urban Studies) and the Physics Department of the University of California, Los Angeles. Traffic noise level samplings were found to be entering East Los Angeles classrooms, parks, old age homes, private residences and housing projects far above tolerable noise levels. The Busway had become the final straw for East Los Angeles and the major thrust of "Impact on Impact" focused on the failure of the "final Environmental Statement" to consider the following:

1. Busway Alternatives: The statement of the two agencies applying for the Federal grant ignores the possibility of using the existing tracks of the Southern Pacific-Baldwin Park Rail line that passes through the communities to be served by the proposed Busway. An alternative may exist for a rapid transit railroad commuter line that could serve San Gabriel, El Monte and other towns in the areas surrounding the San Bernardino Freeway corridor. The Federally subsidized downtown mini-bus program could easily use Union Station as a terminal for rail passengers coming into Los Angeles from El Monte and San Gabriel, making the Southern Pacific track of the Baldwin Park line a logical and economical alternative to the proposed Busway.

2. Potential Visual and Noise Pollution Caused by the Freeway, Busway and Railroad: The need for the setting of noise standards and noise reduction measures for rail, Busway, truck and automotive equipment using the San Bernardino Freeway corridor. The "Final Statement" contains no reference to any landscaping plans that will visually screen out the buses, freight trains and present San Bernardino Freeway traffic from the view of residents living along the corridor.

3. Need for Independent Impact Statement by Railroad Company: Throughout the report, the railroad company is considered to be an incidental 3rd party that has no environmental obligations to the area through which it passes. Amenities such as noise attenuation walls are considered to be possible only if the railroad company agrees to such structures on their right-of-way, and the Division of Highways pays all construction costs. The construction of several thousand linear feet of major retaining walls and a $2,900,000 rail trestle constructed for the Southern Pacific Transportation Comapny by the California Division of Highways using Busway Federal grant funds, brings the railroad under the jurisdiction of Public Law 91-190.

4. Failure of the Division of Highways and the Southern California Rapid Transit District to Carry out the Intent of Public Law 91-190: Federal, state and local government agencies applying for Federal grants are consistently issuing inaccurate, evasive and self-serving environmental statements that fail to consider the public interest.

Our report was filed within the required deadline with the Council on Environmental Quality, the Environmental Protection Agency. Secretary Volpe of the Department of Transportation received "Impact on Impact" two days after he had approved the Busway grant. We don't understand why the Environmental Protection Agency failed to coordinate sooner with the Department of Transportation, on Barrio Planners objections to the Busway Proposal.

Through a television and newspaper publicity campaign we are attempting to modify the worst features of the Busway before the letting of construction contracts in January, 1972. John Pastier's recent column (Los Angeles Times, October 21, 1971) expressed and reinforced many of "Impact's" conclusions in opposing construction of the Busway.

In reviewing the failure of our attempt to halt the Busway we see the Community Design Center as a means of shaping Public Law 91-190 into a formidible public interest and environmental tool if Design Centers will do the following:

1. Relate our community, professional and personal work to the laymen in terms and devices (models, slides etc.) he can understand.

2. Learn the necessary political processes at the state, local and Federal levels in order to express, expedite and implement both politically, legally and administratively the community projects our Design Centers have adopted.

3. When possible, hook the political, legal and educational work of Design Centers to the work of conservation groups and attorneys working in environmental law, as they make new legal precedents through litigation in the nation's courts.

The face of American land, water and air, in the city or the country will not be restored and improved by patchwork planning, nor will it happen if we continue to fail to excerise our political, legal and educational processes in a comprehensive manner.

Appendix A.

SOUND READINGS TAKEN BY BRUCE WALKER (PHYSICS DEPARTMENT) U.C.L.A. - 9/23/70

TIME	LOCATION	READING		AVERAGE
8:00 AM	Closest to frwy. opp. ball diamond	125-75-79		
8:00 AM	" " " " " "	250-72-79		
"	" " " " " "	500-65-72		
"	" " " " " "	1000-59-63		
"	" " " " " "	2000-58-62		
"	" " " " " "	4000-50-58		
"	" " " " " "	C-82-88		
"	" " " " " "	A-66-73	-	70
⊖ (RDNG #1)				
8:15 AM	Opposite Unit 377 Just east of crossing	A-63-65-68		
"	" " " " " " "	C-75-78-85	-	68
◬ (RDNG #2)				
8:20 AM	Directly behind C/L overcrossing wall North side/wall	C-71-74-77	-	72
⊖ (RDNG #3)				
8:25 AM	100 feet south/Lancaster	C-71-74-80	-	72
● (RDNG #4				

8:35 AM ● (RDNG #5)	Approximately 100 yds n. Fwy rear, upper yd. of Santa Teresita School Adjacent to class rooms.	A-58-62 C-71-80	-	60
8:40 AM " ⊕ (RDNG #6)	Southwest Hallway Santa Teresita Sc. 2nd floor, open rear windows 120 yds. N/San Berdo Fwy.	A55-66 C-68-75	-	61
8:45 AM ◎ (RDNG #7)	Classroom off S.W. Hall S. Teresita School, 125 yds. N./ San Berdo Fwy.	A-48-52 C-60-66	-	50
8:50 AM ◉ (RDNG #8)	1st floor classroom, S.W. Wall 4th Grade, 125 yds. n/Fwy.	A-50-57 C-64-70	-	53
8:55 AM ◬ (RDNG #9)	(pedestrian) Adjacent to Fwy Crossing Wall	A-62-68	-	65
8:57 AM ▲ (RDNG #10)	Directly behind pedestrian fwy. crossing wall. 18 ft. high.	A57-62	-	59

Appendix 3.

DATE: February 19, 1971

TITLE: Noise Level Measurements

LOCATIONS: East Los Angeles Community

REASON: To ascertain the intensity levels and sounds in schools and public places, adjacent to Los Angeles Freeway System.

PROCEDURE:
1. Use of a general radio, Type 1551-C sound level meter.
2. Use of the "A" weighted scale.
3. "Eyeballing" an average of the reading from the meter, after observing the meter for three to four minutes.

MEASUREMENT TAKEN BY:
Joel K. Okada
California State College
Dominguez Hills
1000 East Victoria
Dominguez Hills, California
Geography Department

TECHNICAL ADVICE: Mr. Peter White

DATA PREPARED FOR: Los Angeles Community Service Organization and Barrio Planners, Inc.

Ramona Gardens Housing Project: North of San Bernardino Freeway, east of Soto Street.

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
2/12/71 2:00 PM	Lancaster near Murchison	56 dBA	60 dBA	500'
2/19/71 10:30 AM	" "	56-58 dBA	60 dBA	"
2/12/71 2:00 PM	Near Freeway Vanegas Lane	65-68 dBA	75 dBA	225'
2/19/71 10:40 AM	" "	65-70 dBA	75 dBA	"
2/12/71 2:20 PM	Nieto Lane and Lancaster	57 dBA	60 dBA	700'
2/19/71 10:52 AM	" " "	56-59 dBA	62 dBA	"

Hollenbeck Park: Golden State Freeway at Fourth Street

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
1/22/71 12:40PM	West side of Lake	65-68 dBA	72 dBA	100-110'
	East side of Lake on jetty	66-68 dBA	74 dBA	400'
2/26/71 3:05 PM	East side of Lake	67-69 dBA	74 dBA	450'
4/29/71 2:00 PM	East side of Lake in Amphitheater (band shell)	62-65 dBA	68 dBA	650'

Marvilla Project: Housing project north of Pomona Freeway, west and north of Riggin School.

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
2/16/71 12:30 PM	At East Brooklyn	51 dBA		1,000'
2/16/71 12:45 PM	Between east Brooklyn and First Streets	52 dBA	56 dBA	60'
2/19/71 2:00 PM	" " "	51-52 dBA	58 dBA	60'
2/16/71 1:00 PM	At Mednik and East First Streets	64 dBA	73 dBA	60'
2/19/71	" " " "	63 dBA	73 dBA	60'

Belvedere Park: North of Pomona Freeway, East of Mednik Avenue

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
2/16/71 11:50 AM	Middle of park	59 dBA	69-71 dBA	650'
2/19/71 1:30 PM	" " "	58-61 dBA	68 dBA	
2/16/71 11:50 AM	Corner of Pool Nearest to Freeway	64 dBA	72 dBA	180'
2/19/71 1:30 PM	" " "	62-64 dBA	70	"

Fresno Recreation Center: East of the intersection of the Pomona and Santa Ana Freeways.

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
1/15/71 3:35 PM	Middle of park	66 dBA	76 dBA	400'
	North edge of park	68 dBA		60'
	South edge of park	64 dBA		300'
1/22/71 11:55 AM	Middle of park	63-63 dBA	69 dBA	

Aliso Pico Housing Project, Pico Gardens: Pecan and 5th Streets adjacent to Santa Ana Freeway

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
3/5/71 2:00 PM	Corner of Pecan and	68 dBA	80-82 dBA	60'
	Corner of Gless and Lanfranco Streets	59-61 dBA	68 dBA	60'
	Playground in Project	56 dBA	62 dBA	80'
	Playground in Pico Aliso	55-58 dBA	62 dBA	120'
	Outside residence 441 Pecan	66-71 dBA	74-76 dBA	20' from off ramp 50' from freeway

Pecan Playground: First Street and Pecan, adjacent to Santa Ana Freeway

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
3/5/71 3:15 PM	East of old Building (closed)	58-61 dBA	75 dBA	80'
	Near corner of First Street	59 dBA	74 dBA	120'

Riggin School: Southwest corner of Belvedere Park, adjacent to Pomona Freeway.

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
2/19/71 11:00 A.M.	Second Story Overlooking Freeway	52 dBA		120'
	Windows Open (Windows are opened on warm days)	57-60 dBA	68-70 dBA	120'
	Front Steps	69 dBA	77 dBA	90'

McDonnell Avenue School: Northeast of intersection of the Long Beach and Pomona Freeways. On First and McDonnell.

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
3/10/71	Play Area Within Building Complex	52 dBA	56 dBA	300'
	Play area nearer to front arcade	53 dBA	72 dBA	225'
	In hallway	51 dBA	58 dBA	225'
	Outside front of offices	61 dBA	80 dBA	200'

Salesian High School: On Seventh and Soto Streets, across Seventh from Soto Street School

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
3/10/71 10:00 AM	Third Floor Classroom Overlooking Soto			
	(Windows opened)	56-61 dBA	68-71 dBA	520'
	(Windows closed)	48-49 dBA	56 dBA	
	Second Floor	54 dBA	65-68 dBA	520'

Soto Street School: On Seventh and Soto Streets, near Santa Ana, Golden State, and Pomona Freeways.

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
1/22/71 1:11 PM	Upper Floor Soto Side	62 dBA	69 dBA	125'
	Playground	57 dBA	65 dBA	
	Upper Floor Hallway			125'
	(windows closed)	56-59 dBA		
	(windows opened)	66-70 dBA		
	Lunch Area (Also used as area for tutorial program)	68 dBA	75 dBA	100'
	Room farthest from traffic noise	58 dBA	66 dBA	400'

Soto Street Childrens Center: Located on Seventh and Soto, East of Soto Street School

Date and Time	Low Reading	Peak Reading	Distance In Feet
1/22/71 1:45 PM	57-58 dBA	63 dBA	450'
3/10/71 10:40AM	57-60 dBA	66 dBA	450'

Jewish Home for the Aged: Between the Santa Ana and Golden State Freeways, on 4th and Boyle.

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
3/5/71 11:00 AM	Lower Floor nearest to Freeway (Santa Ana) Westside Building	59 dBA		30'
	Outside within ten yards of Freeway	76 dBA	86 dBA	20'

Lack of cooperation made these readings doubtfully accurate. I was not permitted to take readings in any area where people were.

Hollenbeck Home: Between Santa Ana and Golden State Freeways, near 5th Street on Boyle Avenue.

Date and Time	Location	Low Reading	Peak Reading	Distance In Feet
3/5/71 11:55 AM	Upper Floor Dining Room, Facing Santa An Freeway (West side Building)			
	(closed windows)	55 dBA	64 dBA	20'
	(opened windows)	62 dBA	72 dBA	20'
	Foyer	54 dBA	65 dBA	370'
	Outside Front entrance	54 dBA	68 dBA	350'

HARRISON SCHOOL 3545 City Terrace Drive

Office (adjacent to freeway, San Bernardino)	58 dBA		95'
Classroom	52 dBA	61 dBA peak	175'
Outside classroom (on steps)	62 dBA	96 dBA peak	175'
Playground (center)	62 dBA	75 dBA peak	150'

Precipatory Planning

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Frame of Reference: Participatory Planning

Very much unlike scientific experiments, planning operations can seldom be undone. Once a freeway is built, it is likely to remain, for better or for worse. A public housing project, once erected (even if a failure), will not be torn down for some time. In either case, there will be people adversely affected without any remote chance to be compensated in any way. A family that has been dislocated for the purpose of highway construction, duly relocated, and indemnified for loss of property is unlikely to get any redress for less material losses such as severed neighborhood ties or disrupted acquaintances if the freeway later turns out to be a debacle. Nor will the taxpayer, who most probably had no say in the decision to build the freeway in the first place, be reimbursed if the project is unsuccessful; to the contrary, he is almost certainly further drained to pay for the consequences. Similar stories about unfortunate public housing tenants could be told.

These considerations raise the very crucial ethical question, "Does the planner have a moral right to be wrong?" If the answer is no, as we strongly believe it ought to be, the methodological question is raised in turn, "How can the success of a plan, when implemented, be assured?"

Any plan could fail either by not yielding the desired situation and/or by generating undesirable side or after effects. Since it is not our intent to discuss all potential sources of failure, we will look only at those we think relevant in the context of this paper.

A plan is said to be a strategy to remove a discrepancy between what is perceived to be the case and what is believed ought to be the case. What, then, happens to a plan if the anticipated beneficiaries of the plan do not perceive the discrepency in the same way the planner sees it, or worse, if they do not perceive it at all? What if they think that the strategy used to remove the discrepancy is not adequate? Contrary to what the planner from the government thinks, an inhabitant of a dilapidated house may not have a better dwelling unit in mind as a first priority. He may want a decent job or better services for the community he lives in: garbage collection, street lighting, etc. If, on the other hand the tenant of a so-called run-down house agrees with the planner that he should have a better house, he does not necessarily agree with the concept of public housing. The tenant may reject the idea as just another form of discrimination, just another source of suffering. His idea for obtaining a decent dwelling may be rent control to protect him from the exhorbitant rent charged by an absentee landlord. The tenant may argue that in this way he may have some money left over to improve his own condition in his own community.

Planners' misjudgement of people's values, wants, and desires has led, more often than not, to open or covert resistance to their plans or even sabatoge of those plans. That opposition may often come from unexpected directions. Thus, many people who have voted in favor or public housing will finally oppose it when the project site happens to be in their neighborhood. Misfits between the planners' and the people's ought-to-be images may not have existed in a society with a tightly knit fabric of behavioral constraints, but in an open society they have become a serious problem. The cultural distance between any group of people and planners has grown large enough to make it impossible for planners to represent other people's values.

Recognizing these difficulties, Davidoff has suggested that the people for whose benefit a plan is to be drawn up should get an advocate, a person who knows both the affected people's values and the technical language necessary to argue the people's wants and desires with the professionals.(1) It is obvious, and has been demonstrated over and over again, that the advocate pla-ner is caught in the same bind as the expert planner.(2) Since no community forms a homogeneous group and values and interests vary from person to person, there is no hope that the advocate planner could ever represent all individuals in even an approximately adequate fashion.

The consequences are (and it is strange that Davidoff should not have anticipated them) that the people must represent themselves. They are the best experts on their own values, wants, and desires. A planning situation in which the people take affairs into their own hands may properly be called participatory planning.

Participatory Planning: Some Difficulties

Participatory planning, while not a method, is an attitude toward planning which creates methodological and ethical problems of its own. Some of the more puzzling questions participatory planning raises are presented here.

To ask who should participate within the above framework may sound quite silly; however, the question, as we shall show, is by no means trivial. The obvious answer seems to be: everybody. When we say everybody, do we really mean everybody: children, felons, the insane, aliens? Or do we think only of registered voters? Do we consider everybody regardless of where they live or do we think participation should be limited to residents of some particular area. In anticipation of the example to be discussed later, should only the residents of the Rockridge area be involved or should the citizens of adjoining districts in Oakland and Berkeley be included? After all, the residents of the Rockridge neighborhood are not going to be the sole users of facilities in this district: it is anticipated that the location of a Bay Area Rapid Transit station in the heart of the Rockridge will generate a sizable flow of non-residents through the district.

If a decision is to be made with regard to who may legitimately participate, we must ask, "Who is to make that decision and on what grounds?" One may say that everybody who is affected by the plan and its consequences may (or should) participate. Identification of who is affected may be accomplished in a number of ways. Everybody who claims to be affected may be considered a bonafide participant or one might establish a court-like situation in which the "affectedness" of a claimant may be tested through an argumentative process. Administrative standards of "affectedness" might be designed in the same manner that certain criteria "qualify" a welfare recipient.

It is common knowledge that the theory of planning is life with paradoxes. Participatory Planning simply generates another. To decide who is to participate (if such a decision is to be made) is to make judgement about other people's values, judgements we have postulated can only be made by the participants.

However esoteric some of the above questions may sound, they have their correlates in practice. The following description and discussion of an actual participatory planning attempt serves to illustrate this. In particular, it will show the importance of the question, "Who is to participate?" In the case at hand, the initial group may be called "a self-proclaimed group of affected people". What was their base of representation and how did it affect the group's ability to act? How did they sustain participation? Last, but not least, what is the professional planners role in all this?

Participatory Planning at Work: Precipitory Planning

Oakland, California's Rockridge district first started to take form in 1903 when land previously known as the Peralta Reserve began to be subdivided into two and three block developments. By 1911, lots were staked out along Broadway to the base of the hills which lie along the eastern boundary of Oakland. Filling in of vacant tracts proceeded rapidly and an indentifiable residential district formed primarily between Claremont Avenue and Broadway, with College Avenue bisecting the area. The name of one early subdivsion, the Rockridge, was popularly applied to the entire district and remains in use through the present.

Of the dwelling units currently in the Rockridge, 57% were built prior to 1919 and 86% prior to 1929. (3). While most dwellings are single or two family detached structures built mainly of wood, those on the flatlands west of College Avenue generally appear less expensive than those to the east of the street. Additionally, open space, trees, and planting are more visible to the east.

Beyond forming a boundary between the eastern and western portions of the Rockridge, College Avenue possesses most of the commerical, and to a lesser extent civic, activities within the district. After the Grove-Shafter Freeway removed an entire block of this activity near the middle of the district, commercial enterprise south of the freeway appeared to fade while north of the freeway it continued as before or, in some cases, expanded.

In reference to the present residents of the area, the Oakland City Planning Department, in its report Rockridge Station Area, stated, "About 1/3 of the employed male work force is in the professional and managerial categories. Almost 3/4 of the households own at least one car. Median home value and median gross rents in 1966 were about 10% higher than the city-wide average." (4) About 1500 families compose the Rockridge Area.

During the early 1950's, the decision was made to build a freeway linking the north-south freeway system along San Francisco Bay and its connection to the city of San Francisco via the Oakland Bay Bridge with the developing suburban region east of Oakland. Early planning commenced in 1954-1955. A corridor hearing was held in the Oakland Civic Auditorium in December 1956 at which seven alternative routes were proposed, four affecting the Rockridge area and three referring to other porportions of the freeway. After years of debate, during which community groups polarized around each planning

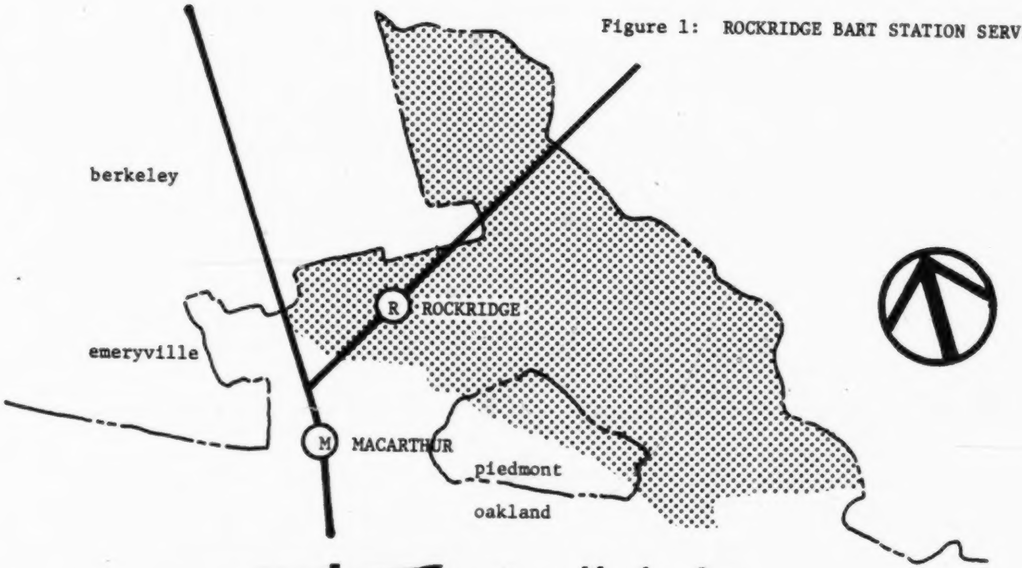
berkeley
emeryville
R
ROCKRIDGE
M
MACARTHUR
piedmont
oakland

Figure 1: ROCKRIDGE BART STATION SERVICE AREA

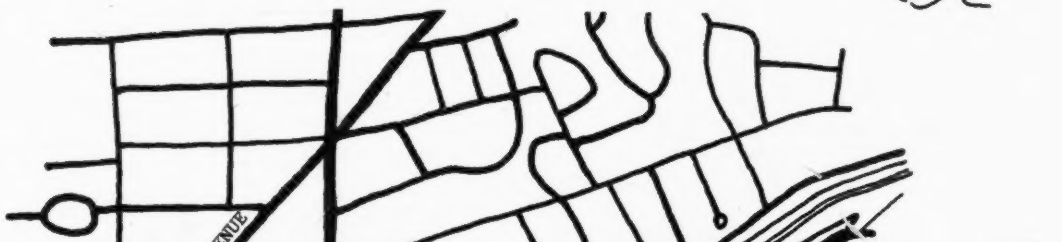
CLAREMONT AVENUE
FREEWAY - BART
COLLEGE AVE
BROADWAY

Figure 2: MAP OF ROCKRIDGE AREA

alternative, the route originally presented as the preferred alternative was constructed. This route also became the path of the Bay Area Rapid Transit (BART) line to the developments east of Oakland.

Physically, the Grove-Shafter freeway runs east-west through the Rockridge, elevated on a high embankment one block in width in the western portion of the district and on-grade in the eastern portion where the hills rise to the level of the road. To accomodate parking at the College Avenue BART station, whose structure rises above the freeway, BART and the Grove-Shafter are elevated on piers and the spaces beneath paved.

Rather than focusing on the environmental impact of the freeway, community concern centers on the potential development impact of the Bay Area Rapid Transit and its College Avenue station. Alleviation of the undesirable effects of the freeway through future planning steps becomes a secondary issue nested within the overriding problem of development within the Rockridge in general.

While most areas surrounding BART stations are locked in to existing economic uses, the Rockridge station area appears attractive to investors. In the Oakland 701 Project Summary Report, the City Planning Department poses a view reflecting city-wide interests in the area's future development. "Emergence of a high-density urban sub-center related to the station would be a dramatic alteration of the area's prevailing low-density character. Such an alteration appears necessary and desirable to capitalize upon the high transportation capacity of the BART system and to take advantage of the rejuvenating investment resulting from it". (5)

While this view coincides with the expectations of some property owners, developers, and proponents of development, it is at variance with the views held by other local residents. Numerous persons are concerned about the potential disadvantages of the projected development which they perceive primarily in terms of environmental and social "degradation" within their neighborhood.

In response to mounting pressure from Rockridge property owners, who are not all local residents, the Oakland City Planning Commission scheduled a public information meeting on 11 January 1971 for the purpose of presenting a proposal to rezone some of the land adjacent to the BART station to accomodate higher density development. The meeting held in the Rockridge's junior high school gymnasium, witnessed a community protest of unprecedented proportions against the City Planning Commission action. While some property owners and developers supported the rezoning, numerous individual residents spoke vehemently in rebuttal. Significantly, a committee of local citizens presented itself as the core of a future planning effort within the Rockridge.

The Rockridge Community Planning Council Steering Committee, an unelected, spontaneously formed coalition of representatives from several other existing community groups acting under the leadership of a popular local resident, presented a proposal in petition form calling for a moratorium on all zoning changes within the Rockridge until planning investigations independent of the City Planning Commission could be completed. Expressing the view that the studies conducted by the City Planning Department were not responsive to local conditions, the Steering Committee proposed that an outside professional planner be hired to formulate an alternative plan based on the desires of the residents. The City Planning Commission, after reaffirming faith in the studies conducted by the staff of their Department, stated that they would delay further action for one month while the Steering Committee sough means to finance an independent study.

At the conclusion of this meeting, we offered our services to the Steering Committee as a resource in support of their efforts. From the beginning of our involvement with this group, we envisioned our role as that of consultants assisting a community effort possessing its own leadership structure. After a preliminary meeting with the Steering Committee's chairman, we were invited to participate in meetings and offer advise when ever we could.

Initially, the Steering Committee concentrated on ways to obtain funding for an independent professional study. As sources of funding were investigated, the group became aware that they could not obtain sufficient financing from public solicitation within the Rockridge, yet were not of sufficiently limited resources to qualify for federal, state, city or foundation assistance. Most programs contacted expressed interest in alleviating existing problems of neighborhood deterioration, but were not constituted or disposed to assist groups attempting to prevent that deterioration from occuring in a presently viable neighborhood.

As the unlikelyhood of obtaining funds became increasingly apparent, we suggested the use of simple techniques for decision-making under conditions of uncertainty to determine some direction for the Steering Committee's future efforts. The issues deemed most important by the committee were continued community involvement, funding, and a moratorium on rezoning in the Rockridge. Using probabilities of occurence agreed upon by the committee, the following results were tabulated:

Involvement	yes	- 70%
	no	- 30%
Funding	yes	- 10%
	no	90%
Moratorium -	yes	- 40%
	no	- 60%

I	F	M	Prob.
y	y	y	2.8%
*y	n	y	25.2
n	y	y	1.2
n	n	y	10.8
y	y	n	4.2
*y	n	n	37.8
n	y	n	1.8
n	n	n	16.2
TOTAL			100.0%

Although the Steering Committee agreed that pursuit of non-funded community-based planning methods (possibly operating within time constrainst) presented itself as the most logical course of action, a few influential members of the committee persisted in the search for funds and in their commitment to obtaining a planner to oppose the City Planning Commission. For other members of the Committee, the possibility of formulating an effective community planning body became a new topic for investigation.

Recognizing that the general educational background of local residents is quite extensive and that several planners, lawyers, architects, and related specialists who might assist a general community planning process live within the Rockridge, the potential for a participatory planning effort was discussed. Two major concerns arose. Suitable mechanics for this effort had to be devised and the issues to be resolved by those mechanics outlined, both with the intention of eliciting maximum resident response.

Key issues were listed for investigation and debate. Among those issues were the following:

> Should rezoning be executed as per the City Planning Department proposal?
>
> Are hign-rise apartments the best means to accomplish develipment goals near the BART station?
>
> Does a market exist for high-rise apartments?
>
> Will immediate rezoning result in sprawling low-rise apartments rather than the high-rise structures set in open space anticipated by the rezoning proposal (a condition recognized by the City Planning Department in the 701 Project Summary Report, but not addressed by the rezoning proposal)?
>
> Should the existing zoning be continued?
>
> Should the area be downzoned to prevent higher density development?
>
> Is zoning the only alternative?
>
> What type of development should be encouraged?
>
> What agencies should be involved?
>
> Which citizens should be involved? Residents only? All users of the area? City Wide interests?
>
> Who should be considered as the clients for this planning?

Additionally, an ethical issue was raised.

> Does a planning body have the right to induce change in a cohesive neighborhood simply because the factors which make it cohesive also make the planning and execution of its development more controllable?

As a means of focusing community attention, an office in a vacant storefront on College Avenue was proposed. Implementation of an Issue Based Information System to co-ordinate debate and resolution of planning issues was discussed. (6) These efforts (although none came to pass) were presented to the City Planning Commission as evidence of the Steering Committee's sincere intent along with a request for further delay of rezoning action. From January through June, the City Planning Commission continued the matter of rezoning from one meeting to the next without any action, first to allow the search for funding and later, when hopes for funds dimmed, to allow the community to develop its own process or process in conjunction with the City Planning Department. In all cases, the approach of a Commission meeting served to stimulate the work of the Steering Committee.

Representation of all concerned interests became an issue which suggested reformulation of the Steering Committee. Interest and a willingness to invest time had been the primary criteria for initial group membership. Impending action by a local merchants' association (unrepresented by the Committee) in support of rezoning developed an awareness that the Committee was not truly representative. This lack of representation coupled with a lack of adequate information dissemination about Committee activities manifested itself in growing community disenchantment with the Steering Committee's self-mandated efforts. To alleviate this latter problem, the storefront proposal was rekindled, the publisher of a weekly local newspaper was incorporated in the group, and a second major community meeting was tentatively scheduled.

Each action by the Steering Committee could more accurately be defined as a reaction. A threatened rezoning brought the group into being. Each City Planning Commission deadline intensified the Committee's work. As the threat of immediate rezoning appeared to fade (while in reality it was merely postponed), the efforts of the Steering Committee diminished as well.

Ultimately, a six month delay of any rezoning a action on the grounds that no development could be anticipated until after BART commenced operation led to virtual discontinuation of Steering Committee activity. In the absence of a stimulus, there was no response.

In the process of working within this stimulus-response context, it became apparent that a series of working papers could stimulate and direct discussion and activity in the Committee. A proposal disseminated prior to a meeting served to focus much of the discussion at that meeting. The working paper became a catalyst for action without taking the dimensions of an advocacy planning attempt. This catalytic process to elicit participatory action might best be described as precipitory planning.

Precipitory Planning: An Outlook

There are some reasons to believe that, although planning should be done by the people thenselves, there is still a definite place for a professional planner. His role is manifold: he may first appear as a work organizer by offering and setting up such tools as Issue Based Information Systems, which display to the group its own work, show progress already made, and point to tasks still ahead. By the same device, the contributions of experts are put into perspective and their influence is more easily controlled. Further, the planner may act as a solicitor of ideas rather t than being a generator or promoter of plans. It is this activity we have termed precipitory planning.

Still another role is that of catalyst. The planner's knowledge, methods, models, and other tools may further help in clarifying confusing situations. Our attempt to introduce notions of decision making under uncertainty may be an example of this.

Finally, we anticipate the potential usefullness of precipitory planning as a technique to identify the participants in a project. If, for example, an Issue Based Information System were installed on a relatively permanent basis in any community, and if the precipitating of ideas were performed systematically, the question of who is affected might more readily find an answer.

There is an inherent danger in this new, or modified, area of involvement for planners. Is the action precipitated by the catalytic process a participatory response or is it the imposition of the planner's will through a more subtle manipulation than the traditional planning process?

In response to this question, we might answer that precipitory planning is not yet a systematic procedure, much less a method. Much work needs to be done before it will become a workable tool. Needless to say, this work should build into the technique the necessary safeguards to prevent precipitory planning from becoming just another tool to manipulate the innocent.

Footnotes

(1)Davidoff, "Advocacy Planning & Pluralism" JAIP.

(2)Peattle, Lisa "Reflections on Advocacy Planning" JAIP XXXIV, March 1968.

(3)Oakland City Planning Department Staff, Rockridge Station Area, p.22

(4)Ibid, P.16
(5)Ibid, p.22

(6)For explanation of the methodology involved see: Issues as Elements of Information Systems by Werner Kunz and Horst Rittel, Development Research, University of California at Berkeley, 1970.

RESULTS OF AN INITIAL FIELD STUDY OF NEW TECHNIQUES FOR CITIZEN PARTICIPATION IN EDUCATIONAL FACILITIES PLANNING

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Abstract

The utility of a particular citizen participation planning approach is described when applied to educational facilities planning.

With the aid of a clear cut decision-making procedure citizens can effectively participate in developing specific planning policy statements. These statements can be used to discuss planning priorities, focus on policy consequences, and evaluate alternative planning and design proposals. With the aid of easily used graphic tools citizens can also produce innovative planning proposals.

Introduction

Bond issues for educational facilities are being voted down by school districts across the country. While administrators and planners are proposing new directions in education, taxpayers are becoming increasingly reluctant to accept any program requiring additional tax money. Citizen participation in difficult school district planning decisions makes signigicant issues more accessible to the voter and provides a forum for the resolution of many educational decisions prior to election day. Unfortunately, some experimental programs which have tried to increase tax payer participation in planning decisions have not provided for the organizational continuity and depth of involvement necessary to translate words into actual physical change. By not providing a coherent decision-making process which citizens can use in carrying through long range plans, many procedures for broad participation eventually dissolve into uncoordinated planning, a loss of a true relationship between ideas and action and the eventual loss of interest or bitterness on the part of participants. Indeed, one-shot planning sessions for long range issues can create additional barriers to needed educational changes in school districts.

Logistical problems in school district planning require careful deliberation over extended periods of time. With time, and the aid of a decision-making procedure, citizens can effectively participate in developing educational policies and producing innovative school district planning proposals. It appears that a fresh approach to citizen participation is required to involve taxpayers in a productive way with the educational issues and personalities that shape the quality of their schools.

Background

Several unrewarding attempts to work with the familiar advocacy approach with non-profit housing sponsors pointed the way toward alternative and more participatory approaches for providing professional planning and design assistance to community planning groups. An example of one project, which led to the initial hypotheses building for the production of the Planning and Design Workbook for Community Participation by Bernard P. Spring and members of the Research Center for Urban and Environmental Planning at Princeton University, is the 17 acre site in Newark, N.J.:

In 1965, members of the Research Center at Princeton were working as advocate planners for several different housing sponsors in the Newark, N.J. area. One group was attempting to gain control of a triangular piece of land on Springfield Avenue near down town Newark. The sponsoring group needed a development plan. They had limited seed funds and wanted to know what was possible. As a research center designed to work on design methods in new ways our group proceeded to develop an exhaustive list of requirements from which a housing sponsor could choose what they wanted to be able to do. The sponsoring group replied to this list with a very wise answer: "We want them all, we want to be able to do all those things."

As advocates we continued to work on the development plan and eventually produced a set of presentation drawings and a list of requirements which everyone agreed they wanted. Unfortunately, in the time it took us to produce the design proposal the political situation had shifted and the 17 acre site was no longer in contention. The new situation left the group with a set of drawings that were no longer of any use. In addition, their seed money funds were used up in the production of the first scheme, and they could not afford to repeat the same advocate process a second time to meet the new context.

The educational benefits of this adventure were very small. During the time we were developing the proposal the sponsoring group was learning next to nothing about the planning and design process. Should the political situation shift a second time and third time they would still be unable to evaluate and change portions of earlier plans that no longer conform to the new political situation. Finally, except for the set of drawings the group had no record of the planning and design decisions. A record of the policies that were implimented in the design proposal could prevent the omission of crucial decisions on revised plans and could also provide a format for public accountability for public agencies, public hearings, and other competing interest groups.

The Workbook Method

As a result of the kind of experience just described the research center began to shift the focus of its efforts toward the development of a planning and design process that could be used directly by citizen groups. The result of the shift in the focus of our work is recorded in the 591 page loose-leaf and open-ended document called the Planning and Design Workbook for Community Participation. This document was originally prepared for the New Jersey Department of Community Affairs as an attempt to provide the emerging Model Cities in New Jersey with an operational model to fill the participation requirements in the Model Cities Guidelines.

The Workbook method is most clearly described in the ten "steps" provided in the instructions to the user. Each of the ten steps is not particularly new. In fact, they pretty much describe the type of behaviors that planners and designers perform day to day. It is the way the steps are grouped and interrelated that make them unique and useful when actually planning for physical changes and carrying out plans into design solutions.

The ten steps are described as follows:

Step 1: DETERMINE ISSUES
What problems do you want to work on?

Step 2: DECIDE ON POLICIES
What actions do you want to take to solve the problems?

Step 3: SET PRIORITIES
How important is each of the actions you want to take?

Step 4: SELECT CATALOG TYPES
How have other groups tried to solve the kinds of problems you are working on?

Step 5: PREPARE A PLAN
How do you want to change the physical make-up of your community and its component parts?

Step 6: ANALYZE YOUR PLAN
How well does the plan you have made meet the policies and priorities you have decided upon?

Step 7: PREPARE ALTERNATIVE PLANS
Are there any other kinds of plans that may be better than the first one you prepared?

Step 8: EVALUATE THE ALTERNATIVE PLANS
How well does each one of the plans you have made accomplish what you want to do?

Step 9: SELECT A PLAN
What plan does your group agree to support?

Step 10: PREPARE A REPORT
How do you tell the people who will help you accomplish your plan what you have decided to do?

There are three basic types of operations embodied in the ten steps of the Workbook method:

The first operation is an open-ended verbal process of defining issues, selecting policies, investigating possible results of policies and placing priorities among selected policies. To perform the verbal operation a community group would be provided instructions, sample issues, policies and policy consequences. (see figure 1 & figure 2) They would also be provided forms which can be reporduced to record issues and policies in the individual style of the community group. The most difficult part of this operation is tied to the ability of any group to discuss the consequences of policy choices that they will make. Even in the best times predictions are not easily relied upon. Expert testimony, reasoned judgements, and the experience of community leaders are the primary tools relied upon to carry-out discussions of policy consequences.

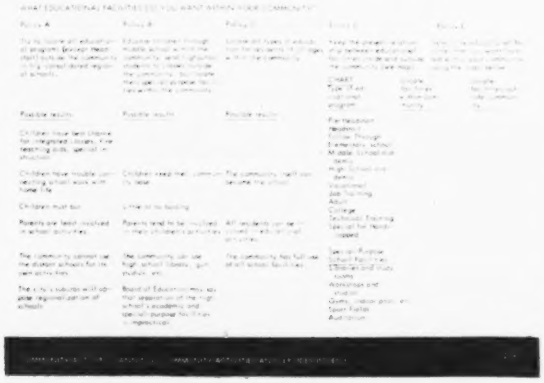


Figure 1

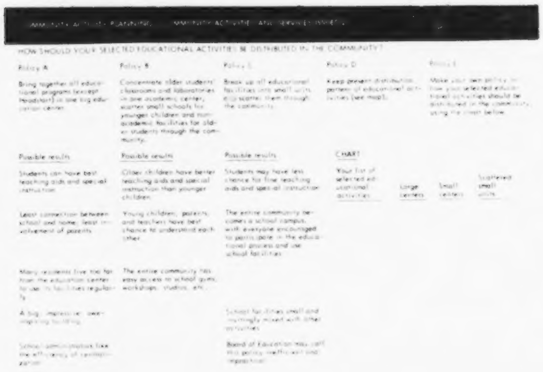
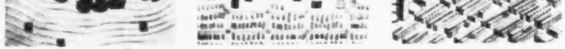


Figure 2

The second operation is an investigation of the kinds of physical forms which might satisfy the policies and priorities which are stated verballly. This operation is usually considered the most fun because it utilizes tools which people with limited planning and design experience can manipulate to produce physical planning or design proposals. In the first version of the Workbook a separate volume and a different kind of physical planning device was used for decisions on the scale of a) the neighborhood, b) the housing site, and c) the dwelling unit itself. During early development stages we discovered that laymen could not easily use these devices for modeling and arranging physical form untill they reviewed a catalog of prototypes that the typical professional carries with him in his head as a result of years of education and experience. The development of catalogs showing existing and other innovative solutions for each of the three scales was perhaps the most demanding part of the Workbook production. (see figure 3 & figure 4 for sample pages from the neighborhood catalog and from the housing site catalog)



DESCRIPTION 7

The drawings below describe a community organized around a long community park extending from one end of the community to the other. A park developed along a river o canal would be an example of this arrangement.

High residential buildings and larger shopping facilities are located along the edges of the park.

Low residential buildings fill the rest of the area along with some daily shopping facilities.

Look at the following Sample Issues and Policies

Residential 9-D, 10-B
Shopping 1-B, 4-B
Outdoor
Recreation 5-D

Figure 3

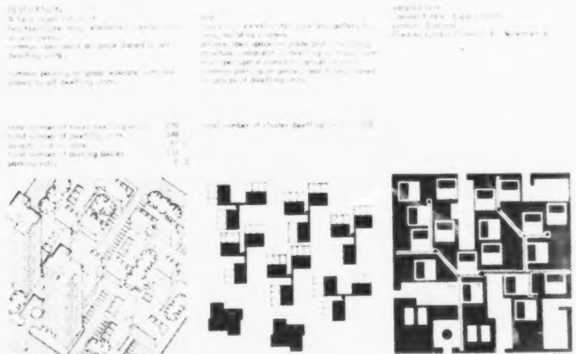
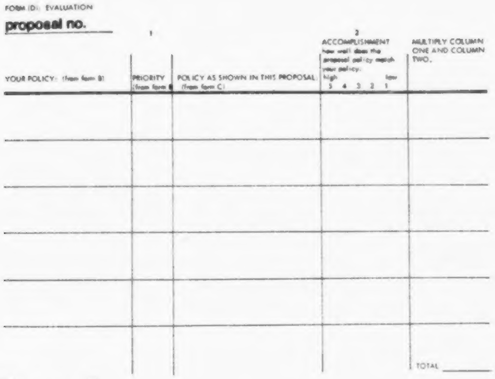


Figure 4

The need for catalogs of this kind was first discovered when, on several occasions, attempts were made to simulate a community meeting with lay-planners. Gaming the Workbook process is difficult. Real issues and real conflicting interests are required. The need for catalogs of prototypical solutions was identified when it was noticed that without past experience or available references no one knew how to lay-out the first design proposal.

The last operation is a rigorous method described for the evaluation of proposed and existing plans for physical change. This operation is perhaps the key to the **usefulness** of the method. The complexity and controversial nature of public planning and design today requires that decision-makers keep track of crucial decisions and provide a format for public accountability. Aids for carrying out this operation are provided in the form of charts and "tally" sheets to record selected policies, analyze alternative physical planning proposals, and evaluate alternative proposals by how well the plans match the policies and priorities of the community group. (see figure 5)



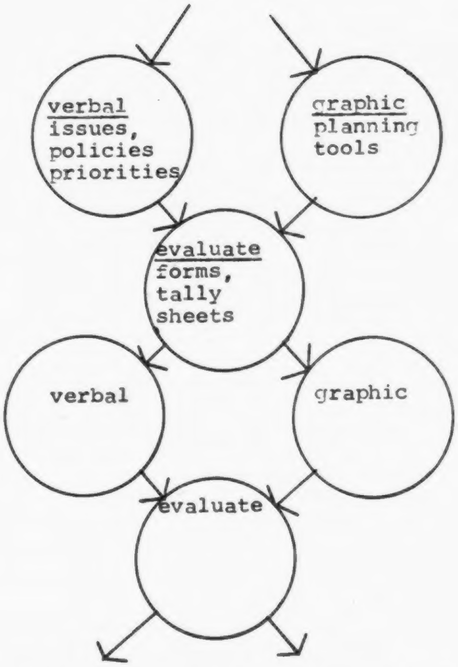
FORM (D): EVALUATION

proposal no. ________

YOUR POLICY: (from form B)	1 PRIORITY (from form B)	POLICY AS SHOWN IN THIS PROPOSAL (from form C)	2 ACCOMPLISHMENT how well does the proposal policy match your policy. high 5 4 3 2 1 low	MULTIPLY COLUMN ONE AND COLUMN TWO.
				TOTAL ______

Figure 5

Although it is suggested that the first time you try this method you start at step one and proceed in sequence to step ten the following diagram clearly presents the iterative nature of the process in terms of the three operations just described: it really does not matter where you start as long as you complete two cycles.



The end product of this process is a program. This is a statement of the problem to be solved. In terms of the three operations of the method the program would include three items: A list of policies the planning group would like to impliment with discussion about the possible consequences of each action; Several diagrams of alternative physical solutions that show how the people, things, and activities that are verbally described should be arranged; And third, a rigouous evaluation of how well each physical solution conforms to the selected policies and priorities.

The first version of the Workbook focused on housing decisions. However, housing construction is not the most popular activity in the existing local New York economy and in the neighborhoods where citizen planning groups are popular. Thus, the first applications of the Workbook method were in the areas of education planning, park and recreation facilities planning, and public financed building evaluation.

Following is a discussion of the Workbook method applied to educational facilities planning:

Application

In November 1969, a Citizens' Advisory Committee was appointed by the Board of Education of Union Free School District #12, Nassau County, Long Island. Given the task of providing the Board of Education with long range and short range plans for the school district the Committee began a long series of meetings. After approximatly twenty meetings the Committee had produced only limited short range results. Long range planning was hampered by the lack of a planning strategy, difficulty in clearly identifying and stating planning issues, inexperience in the production and use of drawings, and some confusion over what the Board of Education expected. In an effort to find the kind of professional help needed to assist the Committee to make plans, the Superintendent of Schools asked the Educational Facilities Laboratory for aid. At this time members of the Research Program at the City College were invited by E.F.L. and the Superintendent to provide "instruction in the use of a planning process for structuring policy decisions, instruction in the use of 'graphic aids' for producing maps and planning proposals, and related data collection assistance necessary for decision making.

Several meetings were held between the Board of Education, the Committee, and the Research Program prior to our first work meeting. In the first week of June 1970 we held our initial orientation meeting. The Workbook method was described in detail with the aid of slides and demonstrations of the planning tools. In turn, we were given a review of why people needed to make plans in School District #12.

The school district boundries enclose portions of three different municipalities:

Malverne, an incorporated community, predominatly white, includes one shopping street and a train station;

Lynbrook, an incorporated community, predominatly white, includes a new public library;

Lakeview, an unincorporated community, predominatly black, includes a new swimming pool complex and boarders a large municipal park.

(see figure 6)

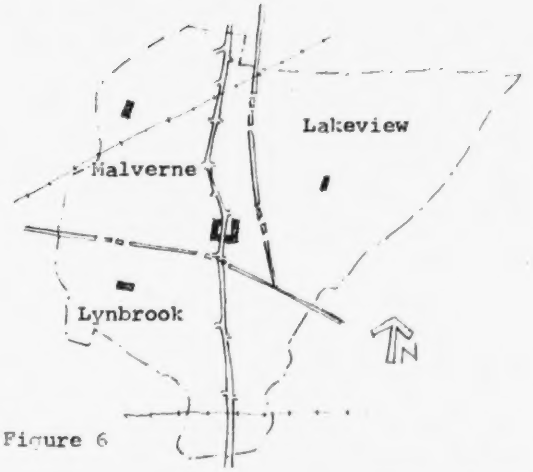


Figure 6

Median income in all three communities is in the middle to upper-middle income range. The quality of housing high: ¼ to ½ acre lots with single family detached houses made of brick and stucco in the Malverne and Lynbrook areas and post-war ranch style in the Lakeview section.

Five school buildings are owned by the school district: Three elementary schools, one in each district; One high school and one junior high school. The two upper schools are located in the geographical center of the school district. This location is one mile from the districts furthest boundry. The quality of the school buildings, like the quality of the housing, is relatively good. The elementary schools are the oldest buildings of the five. The junior high was originally the high school, and the high school is almost new. Each building needs minor renovations and other short term changes, but these were not the planning issues the Committee had difficulty in defining.

School District #12 was an early test for Supreme Court school integration laws in New York State. In June 1970 the school district was in a relatively quite period after a battle over integration requirements that started in the early sixties. Student bussing and the distribution of the elementary school children in the district was the stuff that made the content of most of the long range planning issues.

Several student distribution plans had been attempted by the School Board to balance the elementary school population in the school district: For three years, prior to 1967, the school district was operating under the so called Princeton plan or the 4-4-4 plan. This plan was instituted under a mandate of the past State Commissioner of Education Allen. To impliment this plan state subsidies were required for cross-town bussing expenses. In time the cross bussing became unsatisfactory to a majority of the community and the plan was changed.

In its place the School Board decided on a one-way bussing plan. To accomplish this plan the school in the Lakeview section was closed and turned into a daycare center and offices for school district administration. Relocatable units were rented with state aid and placed behind the two elementary schools in the Malverne and Lynbrook sections. The new relocatable units covered the demand for classroom space equal to the square footage in the unused Lakeview school. (see figure 7)

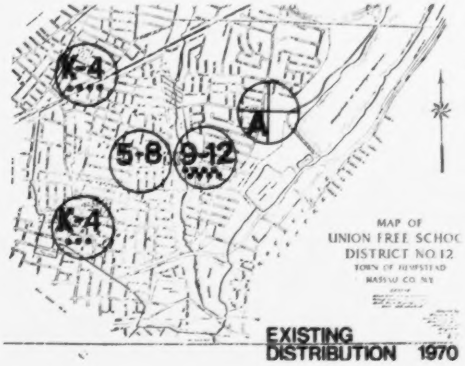


Figure 7

The planning committee was a good example of community opinion. Each member of the Board of Education appointed one representative for a total of nine. After the first orientation session the Committee invited members of other community organizations in the school district to become voting members. The total number of committee members remained stable at about 15 people.

From the first working meeting the group was obviously divided between the pro neighborhood advocates and the pro central complex advocates. Both parties had problems with looking at the component parts of the centralized school or neighborhood school issue. A difficult tactical problem was addressing this issue without the blunt stabs at solutions that had been made in the past, and were clearly being made by members of the planning committee.

Most of the research effort was used to translate minutes of current meetings into clearly stated planning issues for discussion at following meetings. This task included identifying sample policies for each issue and tracking down suppor data for each alternative policy. This approach worked well for the early meetings. When substantive issues were in debate the procedure was slow. Eventually, seventeen issues were raised and policies were selected. The issues are listed as follows:

Issue 1: Who will participate in planning the educational activities and facilities in your community?

Issue 2: What type of communication links should be set up with the Board of Education, teacher organizations, P.T.A., and other community groups?

Issue 3: What time schedule should be established for reporting planning decisions?

Issue 4: What work schedule should be established?

Issue 5: Do you want to plan a school system that will serve a larger or smaller number of students? (see figure 8)

Issue 6: What activities do you want to plan for first? (see figure 9)

Issue 7: Are there any activities which you wish to increase or decrease in existing neighborhood school locations?(see figure 10)

Issue 8: Are there any activities which you wish to increase or decrease in the existing central school locations?

Issue 9: How do you want to group students, and where should they be located?

Issue 10: How far should students travel to get to school?

Issue 11: Do you want to keep relocatable classrooms? (see figure 11)

Issue 12: Who should use the relocatable classrooms?

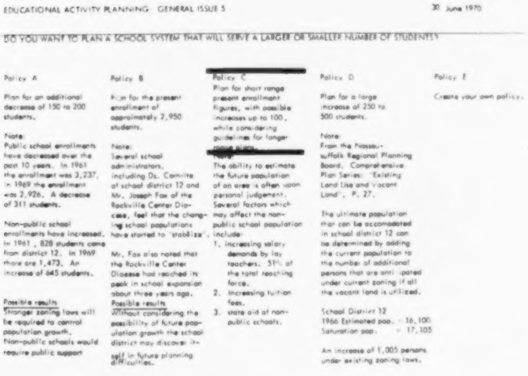
Issue 13: Where should relocatable classrooms be located?

Issue 14: Who should fifth graders go to school with?

Issue 15: Should the Woodfield Road School (Lakeview) be open for classes?

Issue 16: Should neighborhood school sites be sold or leased for other uses?

Issue 17: What type of classroom space is desired for educating students in this school district? (see figure 12)

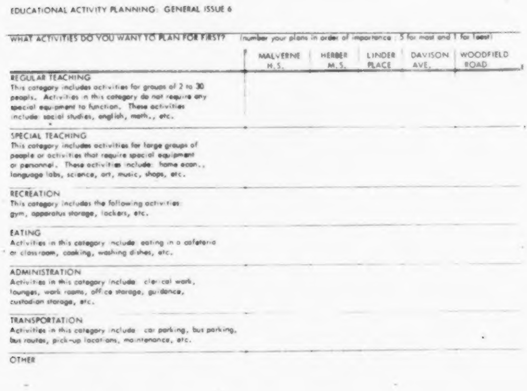


EDUCATIONAL ACTIVITY PLANNING: GENERAL ISSUE 5 — 30 June 1970

DO YOU WANT TO PLAN A SCHOOL SYSTEM THAT WILL SERVE A LARGER OR SMALLER NUMBER OF STUDENTS?

Policy A	Policy B	Policy C	Policy D	Policy E
Plan for an additional decrease of 150 to 200 students. Note: Public school enrollments have decreased over the past 10 years. In 1961 the enrollment was 3,237, in 1969 the enrollment was 2,926. A decrease of 311 students. Non-public school enrollments have increased. In 1961, 828 students came from district 12. In 1969 there are 1,473. An increase of 645 students. Possible results Stronger zoning laws will be required to control population growth. Non-public schools would require public support	Plan for the present enrollment of approximately 2,950 students. Note: Several school administrators, including Ds. Cornvite of school district 12 and Mr. Joseph Fox of the Rockville Center Diocese, feel that the changing school populations have started to "stabilize". Mr. Fox also noted that the Rockville Center Diocese had reached its peak in school expansion about three years ago. Possible results Without considering the possibility of future population growth the school district may discover itself in future planning difficulties.	Plan for short range present enrollment figures, with possible increases up to 100, while considering guidelines for longer range plans. Note: The ability to estimate the future population of an area is often upon personal judgement. Several factors which may affect the non-public school population include: 1. increasing salary demands by lay teachers. 51% of the total teaching force. 2. increasing tuition fees. 3. state aid of non-public schools.	Plan for a large increase of 250 to 500 students. Note: From the Nassau-Suffolk Regional Planning Board, Comprehensive Plan Series: "Existing Land Use and Vacant Land", P. 27. The ultimate population that can be accomodated in school district 12 can be determined by adding the current population to the number of additional persons that are anticipated under current zoning if all the vacant land is utilized. School District 12 1966 Estimated pop. = 16,100 Saturation pop. = 17,105 An increase of 1,005 persons under existing zoning laws.	Create your own policy.

Figure 8

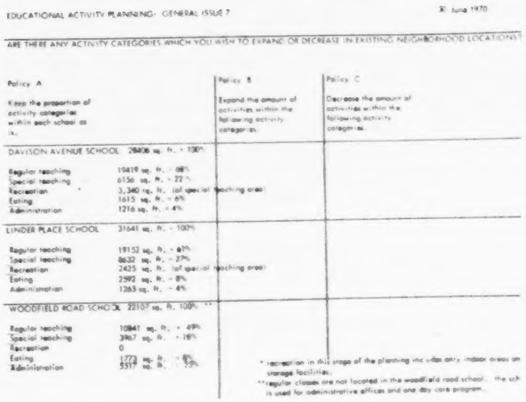


EDUCATIONAL ACTIVITY PLANNING: GENERAL ISSUE 6

WHAT ACTIVITIES DO YOU WANT TO PLAN FOR FIRST? (number your plans in order of importance: 5 for most and 1 for least)

	MALVERNE H.S.	HERBER M.S.	LINDER PLACE	DAVISON AVE.	WOODFIELD ROAD
REGULAR TEACHING This category includes activities for groups of 2 to 30 people. Activities in this category do not require any special equipment to function. These activities include: social studies, english, math., etc.					
SPECIAL TEACHING This category includes activities for large groups of people or activities that require special equipment or personnel. These activities include: home econ., language labs, science, art, music, shops, etc.					
RECREATION This category includes the following activities: gym, apparatus storage, lockers, etc.					
EATING Activities in this category include: eating in a cafeteria or classroom, cooking, washing dishes, etc.					
ADMINISTRATION Activities in this category include: clerical work, lounges, work rooms, office storage, guidance, custodian storage, etc.					
TRANSPORTATION Activities in this category include: car parking, bus parking, bus routes, pick-up locations, maintenance, etc.					
OTHER					

Figure 9



EDUCATIONAL ACTIVITY PLANNING: GENERAL ISSUE 7 — 30 June 1970

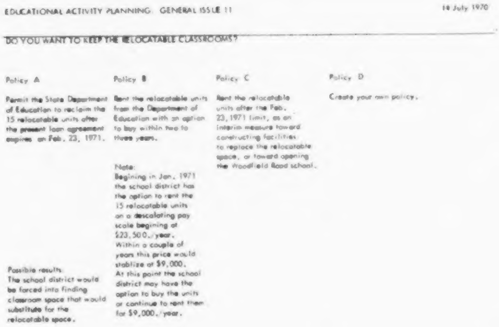
ARE THERE ANY ACTIVITY CATEGORIES WHICH YOU WISH TO EXPAND OR DECREASE IN EXISTING NEIGHBORHOOD LOCATIONS?

Policy A Keep the proportion of activity categories within each school as is.	Policy B Expand the amount of activities within the following activity categories.	Policy C Decrease the amount of activities within the following activity categories.
DAVISON AVENUE SCHOOL 28406 sq. ft. = 100% Regular teaching 19419 sq. ft. = 68% Special teaching 6156 sq. ft. = 22% Recreation * 3,340 sq. ft. (of special teaching area) Eating 1615 sq. ft. = 6% Administration 1216 sq. ft. = 4%		
LINDER PLACE SCHOOL 31641 sq. ft. = 100% Regular teaching 19152 sq. ft. = 61% Special teaching 8632 sq. ft. = 27% Recreation 2425 sq. ft. (of special teaching area) Eating 2592 sq. ft. = 8% Administration 1265 sq. ft. = 4%		
WOODFIELD ROAD SCHOOL 22107 sq. ft. 100% ** Regular teaching 10841 sq. ft. = 49% Special teaching 3967 sq. ft. = 18% Recreation 0 Eating 1773 sq. ft. = 8% Administration 5517 sq. ft. = 25%		

* recreation in this stage of the planning includes only indoor areas and storage facilities.

** regular classes are not located in the woodfield road school; the school is used for administrative offices and one day care program.

Figure 10

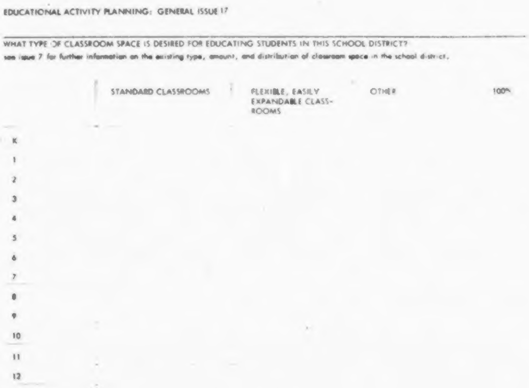


EDUCATIONAL ACTIVITY PLANNING: GENERAL ISSUE 11 — 14 July 1970

DO YOU WANT TO KEEP THE RELOCATABLE CLASSROOMS?

Policy A	Policy B	Policy C	Policy D
Permit the State Department of Education to reclaim the 15 relocatable units after the present loan agreement expires on Feb. 23, 1971. Possible results The school district would be forced into finding classroom space that would substitute for the relocatable space.	Rent the relocatable units from the Department of Education with an option to buy within two to three years. Note: Begining in Jan., 1971 the school district has the option to rent the 15 relocatable units on a descalating pay scale begining at $23,500./year. Within a couple of years this price would stablize at $9,000. At this point the school district may have the option to buy the units or continue to rent them for $9,000./year.	Rent the relocatable units after the Feb. 23, 1971 limit, as an interim measure toward constructing facilities to replace the relocatable space, or toward opening the Woodfield Road school.	Create your own policy.

Figure 11



EDUCATIONAL ACTIVITY PLANNING: GENERAL ISSUE 17

WHAT TYPE OF CLASSROOM SPACE IS DESIRED FOR EDUCATING STUDENTS IN THIS SCHOOL DISTRICT?

see issue 7 for further information on the existing type, amount, and distribution of classroom space in the school district.

	STANDARD CLASSROOMS	FLEXIBLE, EASILY EXPANDABLE CLASSROOMS	OTHER	100%
K				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Figure 12

Policy resolutions to the 17 issues did not just happen one right after the other. During the third and fourth work meetings it was obvious the committee had become weary with words. They wanted to make plans for physical changes but they were tired of talking. The focus of the planning was then changed from using words to using a planning tool to diagram alternative distributions of students and facilities. We would return to the issues and policies at a later time.

A very simple diagramatic catalog of sample arrangements of students and facilities was distributed to the committee members. The committee members quickly adapted this new approach and proceeded to produce alternative proposals.

The tool consisted of two pieces of plastic sheets each 30" by 30". These were taped togeather on one edge to open and close like a portfolio and make it possible to stand as a triangle on a table or chair. Attached to one of the surfaces was a thin piece of cardboard with a thin sheet of metal laminated in its middle. On top of the cardboard several maps were attached with paper clamps: a street map, a vacant and public land map, and a land use map. The movable parts of the tool were various shaped flat pieces of rubber coated magnets. Each small round magnet represented 20 students in a particular grade from kindergarden through 12th grade. The larger square, round, and triangular magnets represented 2,500 sq. ft. of one of the following activity categories: (see figure 13 and 14)

Regular teaching:

This category includes activities for groups of 2 to 30 people. Activities in this category do not require any special equipment to function. These activities include:social studies, english, math, etc.

Special teaching:

This category includes activities for large groups of people or activities that require special equipment or personnel. These activities include: home econ., language labs, science, art, music, shop,

Recreation:

This category includes the following activities: playing indoor sports, apparatus storage, showering and storing cloths, etc.

Eating:

Activities in this category include: eating in a cafeteria or class room, cooking, washing, storage, etc.

Administration:

Activities include: clerical work, lounging, storage, guidance counciling, custodial duties and storage, etc.

Transprotation:

Activities include auto parking, bus parking, bus routes, pick-up, bus maintenance, etc.

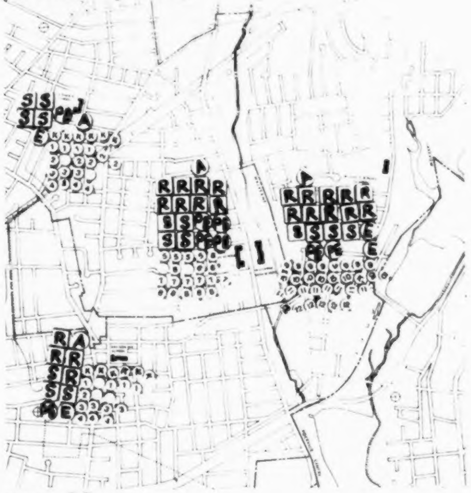


Figure 13

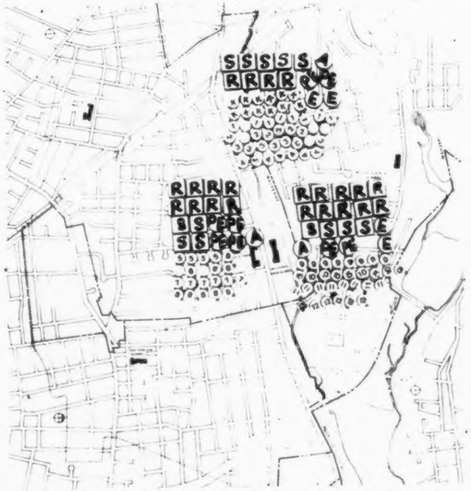


Figure 14,

Using the planning tool at the early meetings seemed to provide the planning committee with an incentive to produce and discuss alternative solutions. By rearranging, adding and subtracting magnets, and quickly photographing the results and recording the data the committee began to ask more in-depth questions about their basic split over the central complex or neighborhood distribution issue. Within three meetings the committee had developed all the strategic planning alternatives they could think of and were looking for a way to sort out the alternatives they wanted to study in depth.

Once again we shifted gears and returned to the verbal problem of identifying issues and selecting planning policies as a way to develop our criteria for evaluating the thirteen alternatives developed with the planning tool.

Eventually, three solutions were selected for presentation to the Board of education. Even with the aid of evaluation forms the evaluation process was difficult. A January 1971 deadline was quickly approaching and our grant money was running out. In addition, a consensus among the committee was not always possible. Members of the committee would disagree on the importance of a specific policy or the feasibility of a part of a particular solution. The tactic that was finally adopted to progress with the evaluation was to include a majority and minority report. This tactic worked on two levels: First, a consensus was taken of the group on any planning decision. If dissention was known the dissenting members would record their prefered policy and produce their own list of criteria. Second, when the first, second and third choice plans were selected the minority opinions for the second and third choices were included in the text of the final report.

Of the three plans for future development the proposal shown in figure 15 is the one most prefered by consensus of the members of the planning committee "given the resources and the support of the community."

By implimenting this plan the planning committee felt that residents in the school district would derive benefits from a decreased bussing budget through shorter travel times and shorter bus routes from cross-town locations to this central "educational campus." The language had tempered considerably from the early meetings. For example, the committee agreed that the "strength of any new proposal for new construction is closely tied to a reasonable and profitable sale or lease of the three neighborhood school properties. Particular attention must be paid to the sale or lease schedules and design, construction and student relocation schedules..."

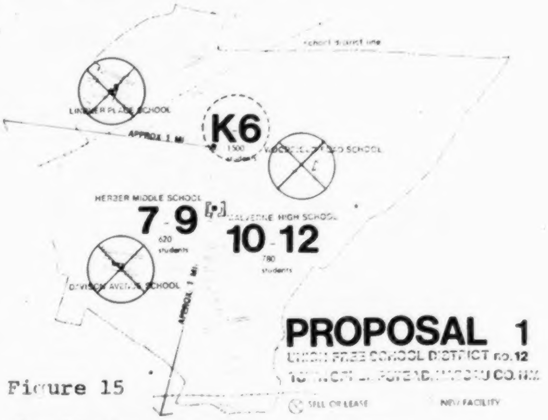

school district line
LINDNER PLACE SCHOOL
APPROX 1 MI
K6
1500 students
SCHOOL
HERBER MIDDLE SCHOOL
7-9
620 students
MALVERNE HIGH SCHOOL
10-12
780 students
DAVISON AVENUE SCHOOL
APPROX 1 MI
PROPOSAL 1
UNION FREE SCHOOL DISTRICT no.12
SELL OR LEASE
NEW FACILITY

Figure 15

Should the community not support the arrangement of facilities in proposal 1 then proposal two would be the strategy to group students in the school district. (see figure 16)

This proposal was not a suggestion to return to a neighborhood school concept. It will take careful planning to move all K-5 students to and from their assigned schools. The major point of contention with this scheme was the trade-off between the lack of educational value for bussing and the maintainance of racial balance.

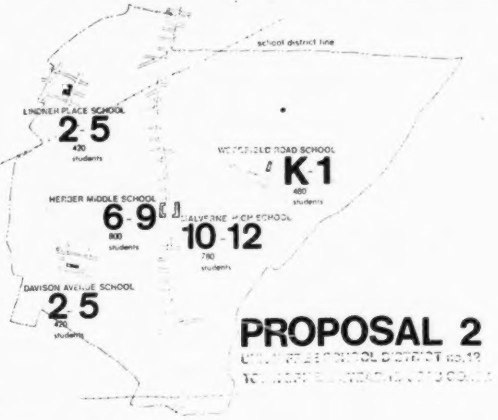

school district line
LINDNER PLACE SCHOOL
2-5
420 students
ROAD SCHOOL
K-1
480 students
HERBER MIDDLE SCHOOL
6-9
800 students
MALVERNE HIGH SCHOOL
10-12
780 students
DAVISON AVENUE SCHOOL
2-5
420 students
PROPOSAL 2

Figure 16

The third plan was the result of trying to find a money saver scheme. (see figure 17) This plan takes into account the possibility of making the temporary classroom units more permanent by applying a fire-resistant facade and replacing other fire risks with more reliable material. The cost of moving the relocatable units from their locations behind the two neighborhood schools and the high school to this new central location would have made the initial costs very high without the additional renovation costs. This scheme was quickly overshadowed by schemes one and two.

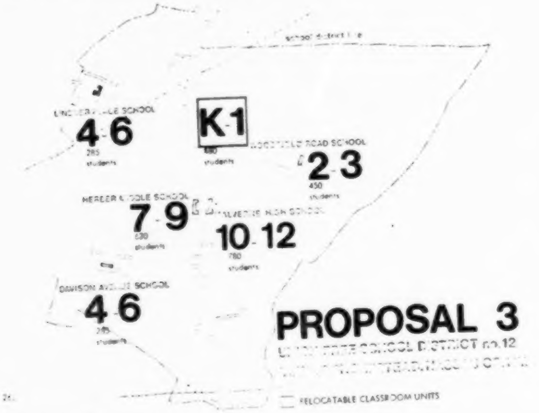


Figure 17

Our last meeting was on the 5th of January 1971. The planning committee was provided with the final copy of their planning decisions. This 28 page report included a list of their issues and selected policies along with diagrams and descriptions of the three planning proposals. In addition, they were provided with a 300 page appendices that included the minutes of all meetings, all working documents and sample materials, a vacant and public land survey, and related statistics on the student population and the five school facilities.

Discussions between the Planning Committee and the Board of Education in School District #12, Nassau County, Long Island are continuing.

Conclusions

Some comments about the methodology, the content, and technical assistance seem required at this time.

First, the method: The idea of laymen completing three operations involving highly technical material and requiring much patience and perseverance appeared impossible in the begining. But as the committee began to find their legs after working through the issues and policies, working with the tool, and having a product to evaluate and a way to evaluate it the flexibility of the method became more useful. We could switch from developing physical plans to discussing highly detailed renovation issues, for example. We could clearly state what the problems were and what our solutions would be.

The problem areas defined by the seventeen issues are a reflection of the make-up and temperament of that particular committee. Other issues could have been discussed. For example, the teachers on the committee were distressed that more "real education"issues, like issue 17, were not raised. In the original version of the Workbook three different scales are available for planning decisions. This planning effort would have followed the same lines; the first step was the school district, the second would be the school site and the third the class room itself.

And finally the role of the technical assistant: Without assistance to guide discussions when they bog down, to provide the necessary data collection service, and to act as the mainstay in long term planning efforts citizen participation efforts of this kind would provide little aid to people who want to have a choice about how their environments are changed.

Notes:
A critical review of the Workbook by John Morris Dixon appeared in the Architectural Forum, Vol. 131. No.5, Dec. 1969, pp 32-39.

In the near future the results of a user survey will be available from Lance J. Brown, School of Architecture, Princeton, N.J.

For additional information on the use of the Workbook for Park planning or Building Evaluation contact Gordon A. Gebert or Carmi bee, School of Architecture, the City College, 138th St. and Convent Ave. N.Y.C.

COMMUNITY RESEARCH. RESEARCH COMMUNE?*

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Since Becker (1) first challenged sociologists to examine critically the role of the researcher in advocating his position in relation to the position of his research subjects, a number of colleagues (2) have questioned whether investigators should adopt a partisan stand and thus lose sight of the objectivity of their research. At the same time, investigators, such as Josephson (3) and Beck and Adams (4) and others, are increasingly addressing themselves to the serious issue of resistances by community residents to research and suggesting ways of getting around these blocks. The concerns expressed by investigators who deal with community problems revolve around the relevancy of studies to the community residents and types of strategies researchers can adopt to assure themselves that they can gain entry into communities. At the same time, they are also concerned that the data gathered would reflect the views of the community residents.

For years, with a few exceptions, sociologists or anthropologists -- for that matter, even the practicing professions -- have been defining relevancy of their studies and practices as it pertains to them or their academic communities. We ignore the wants of the community that we study. In fact, we often stipulate that no one else, least of all, community residents who are defined as laymen with little or no technical competence, should dictate what we look for or how we interpret our data. The studies done earn us academic credentials and we somehow feel we have discharged our obligations to the community.

Now, we are challenged by these residents who demand that we show how our studies are relevant to them. They adopt many ways to keep us out of they do not feel the legitimacy of our presence. They can quickly spread the word through their networks that no one should talk with the investigator. They may demand payment. They may allow the investigator to talk with them, but they deliberately feed false or "put-on" information. Finally, they may simply deny access. If the investigator can gain entry, community residents often want control over the way data are interpreted and their views presented.

Even though the present concerns of sociologists may be an over-reaction of our own guilt feelings, stemming from naivete, the desire of residents for community control into the area of research is very real. As concerned citizens we need to find appropriate ways to resolve some of the problems that we have mentioned above. During the past three years, we have singly or jointly carried out a number of community studies (5) which have given us some experience in dealing with the problems of entry, relevance, and community views. From what we have learned, we feel very strongly that it is time that sociologists should talk less about community research, where our subjects are community residents, and we should try to achieve a state of research commune, where community residents can be partners in research. In this paper, we will outline what we mean by the concept of research commune, and we invite participants to discuss the implications of this commune way of doing research.

Tradition, Knowldge and Research

Before we discuss the concept of research commune, we would like to cite an incident which happened at the 1971 Eastern Sociological Society meetings. At a session on citizen participation in urban decision making, organized by Professor Morton Rubin, one of the panelists who has had considerable experience dealing with neighbourhood groups through her work with O.E.O. poverty agencies, mentioned that many residents understand the ins and outs of planning and they come to some reasonable terms regarding the total planning aspect of some project. A sociologist in the audience said that there was a resident-planner, with only a B.S. in history, who was making all kinds of decisions. This sociologist felt that the B.S.-historian does not have all the qualifications to make these decisions. In a rather exasperated tone, the sociologist in the audience said, "Well, I guess all my seven years of training to get my Ph.D. has been wasted."

We are still very hide bound by the traditional and an elitist view that seven years of hard work has gained us certain kinds of knowledge that community resident do not have. We assume we have the skills that would allow us to make decisions for that community. Through the elitist point of view, some of us want to maintain this status quo system.

On the other hand, community residents question this type of reasoning. They may not be able to quote statistics or draw bar charts in a very sophisticated manner. However, they have lived in the community for a long time and they feel quite adequate in thinking through a problem once they have had some exposure to the way these statistics could be organized for better planning. Besides, they feel that they will still continue to live in the community and they will have to live with the consequences of the research, once the investigators leave. They are no longer willing to be sideline onlookers while some outside group makes what they feel are unrealistic studies about their communities.

Toward a Research Commune: A Methodological Innovation

In order to bridge the widening gap between the community and researcher, we propose that a methodology be established whereby research communes can be started. The term "commune" usually implies living together among other things; we use it not in this sense, but to denote equality and sharing in the research process. Since this simple-sounding idea in reality is quite difficult to set into practice, we should like to describe our attempt to establish one.

One basic assumption behind the research commune as a method is that community residents have the skills necessary to accurately delineate and articulate the social dynamics of which they are a part. Whether one is studying aging or Chicano family structure, this assumption seems to hold true.

Another equally fundamental assumption underlying the research commune is that the community residents about-to-be studied be given the opportunity to make research decisions equal to the professional researcher who desires to do the study. Since reesearch methodology is basically a cumulative decision-making process, the assumption is that community residents will have the opportunity of achieving parity with the researcher as they myriad research decisions are made.

Establishing a research commune is an excruciatingly intense form of social exchange between researcher and community residents. In this paper, we deal with this process between two investigators and their community counterparts while starting a study in Boston's Chinatown (not some nameless "community in a crowded city on the Eastern seaboard, latitude 73° and longitude 14°"). Let us quickly mention that the Chinese community is far from poverty stricken
however, the broader issues are very central to poverty or any other kind of research.

Obviously an entire community of 3,500 persons could not actively participate in a research commune, thus the exchange usually is between the research investigator and a group of residents who are centrally involved in community action. Each has an agenda: the investigator wants to get his study done and the residents want something out of the research. They may want their side of the story heard or they may wish to air their grievances. Ultimately, the investigator receives tenure points for his efforts and the community group may achieve a much needed action program by dint of the research project.

Upon entering Chinatown with an idea for a research project, as a first step we located that group which had been officially designated by the Chinatown power structure to bargain with outsiders. Since our idea for research focused on pathways to health care, we met with the Health Projects Task Force of the Chinese-American Civic Association and proposed setting up a research commune. Once it was determined that there was common interest and need for the proposed research, an ad hoc group of community persons together with the researchers was formed and the research commune began to develop.

The group consisted of eight Chinese community residents as well as the researchers. The first task involved the writing of a position paper which established the structure and functions of the commune. A chairman was elected and meetings were held as often as necessary to design and implement the research project. The burden of translating methodological principles into a form commonly understood by the commune members rested with the researchers and also during meetings the other commune members relied upon them for the pros and cons of given research decisions.

It was decided jointly that the members of the commune would have equal power and that the commune would make all the research decisions as a unit. In addition to the usual decisions regarding design and implementation of the research per se it was decided that the commune members also should screen all new proposed research and all publications emanating from studies in Chinatown. The commune reserved the right of complete control on all such publications. All obligations and rights were put in writing in the position paper which became the formal statement of the policy of the research commune. In short, the community participants and researchers became colleagues or equal partners in the research effort. After the commune had decided upon the data gathering method, the design of questions to be included in the interview schedule, the method of entry into homes and the hiring of interviewers, the commune officially blessed the study and we were then able to complete 200 interviews with only three legitimate refusals and preliminary results have been published by the commune.

Objectivity, Relevance and Credibility: Problems Facing the Research Commune Method

The objectivity of our work as social scientists is a value which most of us strive to achieve. The logical positivists have convinced generations of researchers to be "value free" and to assume a "detached perspective" by not allowing oneself to feel personal commitment to his research "subjects". We agree with Guttentag (6) and La Ruffa (7) that current urban researchers cannot do value-free research. Furthermore, in establishing an urban research commune the researcher must shift his goals to accomodate the goals of his community peers and he must actively take their point of view on matters of grave or primary concern to the community. This is not to suggest that the researcher must never disagree with community residents but he must line up with the basic values (for example, culture oriented and free health care for the poor in the community) and goals of his community peers in order to set up and maintain the research commune.

Does his lack of objectivity in the positivistic sense render his research products less than valid and reliable? We were quite concerned about this question since the community needed a good rigorous study to convince granting agencies of the unmet community health needs. In fact, a community commune member raised the issue when he stated:

> A Chinese representative was coopted from his community tasks because he got too friendly with the hospital people he was negotiating with. He began to lose his objectivity and lose sight of the community objectives. He is now, because of his new friends, more responsive to the hospital people than to the Chinese community. You, Dick (Hessler), will be experiencing the same thing. You will become a public relations man for us here in the community and you will lose some of your objectivity. It is an honor for us but it is not good for you and your scientific work. There is a very thin line between objectivity, community research, and public relations.

This is certainly reminescent of the classical story of the anthropologist who became a priest to the people he studies and henceforth ceased to communicate his findings to his colleagues (8).

While we do not have any real evidence in the sense of research to determine whether or not the lack of researcher "objectivity" interferred with the validity and reliability of the study, it is our impression that validity and reliability were enhanced through the commune, ignoring for the moment the point that the research at least was completed which was more than would have happened if the researcher had attempted the study on his own without establishing the commune. On the one hand, construct or item validity was improved through the intervention of the commune members who frequently re-phrased interview items in order to make them more intelligible to the respondents. Furthermore, questions on substantive areas such as blood letting and receiving were added by community persons after the researchers had missed their import in their musing about what questions to ask. Had we been able to convince community residents to submit to an interview without the sponsorship of the commune, a highly unlikely event, the bias in the data would have been significant and our findings would have dubious credibility. This was told to us several times by community residents who informed us that a researcher who was a stranger to the community with no community contacts and support would find few willing respondents and what little data he was able to collect would represent half truths at best. In short, community participation seemed to serve the purpose of reducing or preventing bias in the data by making the questions more relevant and easier to understand as well as by convincing residents that the study was of merit to the community and thus demanded their careful and accurate cooperation. Investigator bias was less problematic, not because it was absent, but rather because it was effectively dealt with by openly discussing it within the context of the research commune. Toward this end, the commune members constantly questioned the assumptions underlying decisions to include certain interview items to the exclusion of others. We shared some anti-medical establishment perceptions;however, a conscious effort was made not to allow this to dominate our thinking as research plans were developed.

The question of the relevance of the research was another problem associated with the functioning of the research commune. As researchers we were certain that the study would contribute to the sociological literature on medical care and minority groups and thus prove relevant to our discipline. It was less clear that the study would be relevant to the community and the commune helped deal with this issue. Relevance in urban communities is frequently expressed by residents asking the researcher, "What can this study do for us, for the community?" They are demanding that findings be directly applicable for community action programs and, while many community residents can understand that the field of sociology stands to gain substantively and methodologically from the research, this consideration is understandably low on their priority list. The commune members asked this question early in the development of the study and the research was designed around the conclusions of those discussions. For example, it was decided that a neighbourhood health center for Chinatown residents was a high priority item. The commune recognized that data concerning health needs and medical care consumership was necessary and it was decided that rapid analysis of these data would accelerate the grant application for the proposed center. Thus, there was little if any doubt that the results would be directly applicable to community action since the issue of relevance was resolved by the commune early in the research process.

The issue of the credibility of the researcher to the other commune members is the most critical one since the success or failure of the exchange process depends to a great extent on the degree of trust of researcher and community persons. Unfortunately, this also was the most difficult problem facing our effort and one which has not been satisfactorily resolved.

There are two major constraints which operate to encourage a "credibility gap" between researcher and commune members. One is rooted in the ethnic, racial, or background differences among the researcher and commune members. For example, a middle-class, white Catholic sociologist might find it difficult to relate to working-class Mexican community organizers simply because the gamier strategies of conflict and conflict resolution which are necessary for the Mexican community may be frightening to the sociologist. In our case, one researcher was white and he had little or no idea what it meant to be Chinese and live in Boston's Chinatown. Cultural incongruities would intrude at times and would adversely affect the exchange process, although not to the degree to which the research and interaction was seriously hampered.

The other constraint was more serious and it stems from the researchers' innate desire to publish their findings and the community persons' equal fear that publications will hamper the efforts to organize the community by bringing unwanted notoriety to the community or violating the residents' confidence. For this reason, the commune retained the power to ultimately decide the fate of all manuscripts emanating from the project. At times, sections of research reports which seemed perfectly innocuous to the researchers were deemed irrelevant or offensive by the other commune members and these sections were deleted. It seemed at times that some of the disagreements along these lines stemmed from the inherent differences in perspective between the researchers and other members of the group. For that matter, while all commune members shared a social action orientation, the researchers' interest in making contributions to sociology and to publish in sociological journals was not shared by the other members of the commune. We have not been able to effectively resolve this issue to date although it is recognized as a potential source of serious conflict for the commune.

On the other hand, several events have occurred which have helped to build mutual confidence and credibility. For example, one researcher had the instant opportunity to present a paper on some aspects of the Chinatown data and he declined because the commune members had not yet had a chance toreview the material. Also, the researchers have made a special effort to control the tendency to become a patron of poverty or a patron of the community, a role whose consequences could be disasterous for the researcher and commune.

Conclusions

It is difficult if not impossible to draw definitive conclusions at this time and say that we have worked out a new all-purpose method for urban research. Rather we treat the research commune as a single case where a community action group and two researchers formed an alliance for the purpose of conducting a joint research project. We have demonstrated in a very limited way, the feasibility and desirability of developing research communes for urban research. This is a new method and it demands serious evaluation in order to test its utility for urban researchers. Thus far, sociologists have utilized information as knowledge for themselves rather than utilizing knowledge as a member of the community. This again comes back to our training as objective scientists where we seem unable to become genuinely involved with the communities that we study. When we suggest that the community should have an opportunity to control and to react to the research process, we are, in essence, saying that they should act as peer reviewers also and pass judgement on the worthwhileness and relevancy of the study. Not only should we pay adequate attention to the community view, but we should actively publicize these views, either by having the community residents (as research subjects) appear at academic meetings (9) or by finding journals or publishers who would publish their words. Although some of the more vocal residents have sources for publication through media such as the National Welfare Rights Organizations newspapers or the Health Policy Advisory Center publications, there are too few published reactions of community residents to studies that are done about them.

Community residents up to now have not had such veto power over studies in their neighbourhoods and communities. Consumer movements and other social movements in urban areas have rapidly begun to change this picture. As social scientists interested in the urban scene, our research strategies or methodology also have to change if we are to continue our urban research efforts. We can no longer assume the omnipotent role. When we propose a research commune, we suggest just this kind of a change, involving a joint venture in research. This is pragmatic from both sides. The community gains relevant findings and we may gain entry. However, in these kinds of gains, this should not be seen as a game; for the community is deadly serious about relevancy and not being used to test sociological theories of one kind or another. This latter type of thinking can net us a deserved ZERO. The community gains nothing and they can justifiably continue to point to us as villains. Through research communes we have begun to think through the problem and perhaps find a solution to relevant research in hitherto closed or closing communities. The alternative to involving communities in research, we are afraid, is either no research or research which with majestic determination will be completed, nicely bound, and placed on a shelf to gather dust.

Notes

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19: STORING AND RETRIEVING DESIGN DATA

DATA MANAGEMENT TECHNIQUES APPLIED TO PEOPLE/ACTIVITY RELATIONSHIPS WITHIN THE BUILT ENVIRONMENT

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Abstract

The effort to describe people/activity relationships with respect to an institutional environment must address itself to three major concerns: the information necessary to adequately describe these relationships; the method by which this information is obtained; and the structure by which this information is organized to permit analysis (immediate storage, retrieval, and dynamic modification). These three concerns form the initial juncture within a process of decision making. The response to these concerns are crucial to the validity of the decisions made throughout the remainder of the process.

Each of the previous concerns will be discussed with respect to a study sponsored by the State of Louisiana to identify the relationships and requirements for a new facility for the Louisiana State School for the Deaf. Emphasis, however, will be placed in this presentation upon the generalized file management by which this information was organized: RFMS (Remote File Management System).

People/Activity Relationships

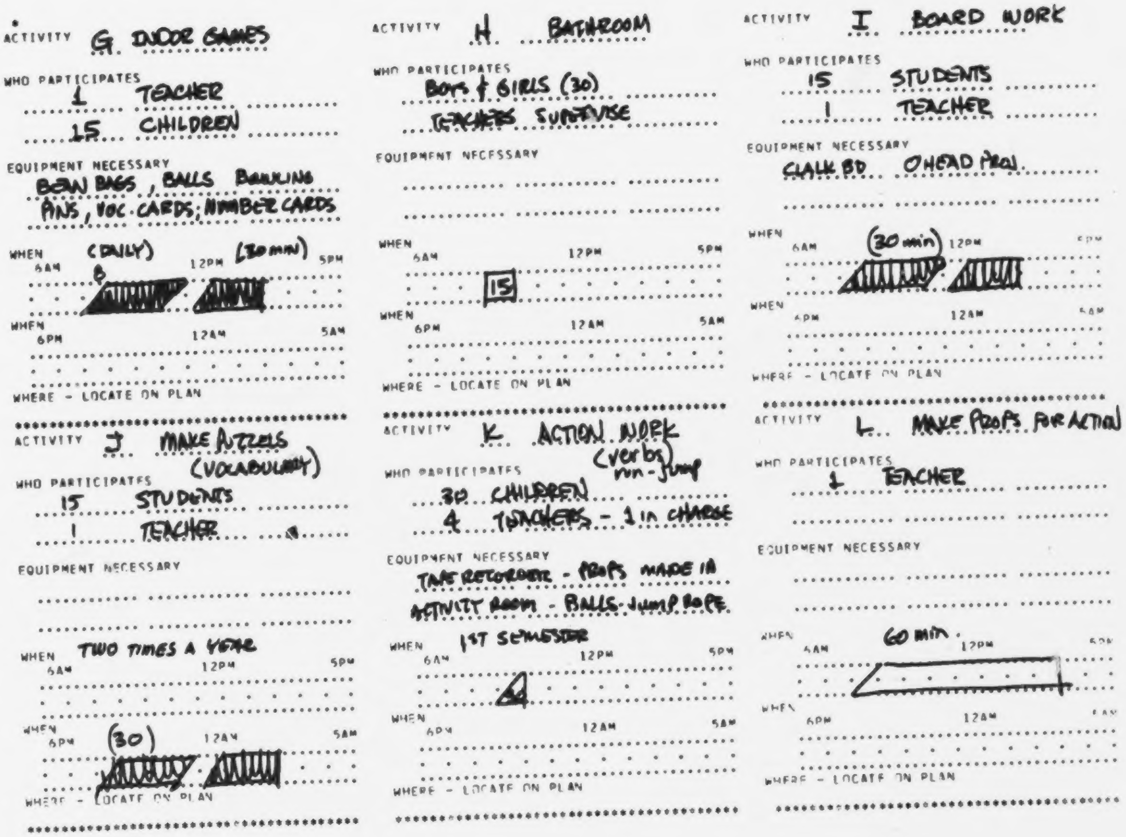
The Louisiana State School for the Deaf study (hereafter referred to as LSSD) involved, basically, an educational institution. However, a majority of the students and some of the staff members were housed on campus, introducing residential and inherent social requirements. The LSSD problem, unlike problem-types primarily oriented to economic or technical constraints, is "people" oriented with respect to:

- WHO uses the facility?
    - Who are the individual people, groups, and categories.
- WHAT activities do they perform to require the use of the facility?
    - What are their needs, interests, responsibility, and authority?
- WHEN do these activities occur?
    - What time(s) of day?
    - For what duration?
    - How often (occurrence)?
- WHERE are these activities located?
    - Horizontal proximity.
    - Vertical distribution.
- WHAT equipment is necessary to perform this activity?

Method of Information Acquisition

In order to extract the necessary data regarding a description of the activity relationships within the LSSD, a questionnaire was prepared, which was intended to compile, in one pass, the majority of the information outlined in the previous section. Approximately fifty faculty and staff members participated in the program, responding to the questionnaires relative to their own activities, the activities of their respective students, and in some instances, the activities of their subordinate staff members.

The questionnaire cover sheet identified the "person" (in the sense of position rather than individual) to whom the following data was to be keyed. This position was described by three classes of relationship, e.g., interdepartmental, intradepartmental, and individual. The following pages (Figure 1) were each divided into six areas, one for each activity performed by the "person" identified on the sheet.



ACTIVITY G. INDOOR GAMES

WHO PARTICIPATES
1 TEACHER
15 CHILDREN

EQUIPMENT NECESSARY
BEAN BAGS, BALLS BOWLING PINS, VOC. CARDS; NUMBER CARDS

WHEN (DAILY) (30 min)
6AM 12PM 5PM

WHEN
6PM 12AM 5AM

WHERE - LOCATE ON PLAN

ACTIVITY H BATHROOM

WHO PARTICIPATES
BOYS & GIRLS (30)
TEACHERS SUPERVISE

EQUIPMENT NECESSARY

WHEN
6AM 12PM 5PM
15

WHEN
6PM 12AM 5AM

WHERE - LOCATE ON PLAN

ACTIVITY I BOARD WORK

WHO PARTICIPATES
15 STUDENTS
1 TEACHER

EQUIPMENT NECESSARY
CHALK BD. OHEAD PROJ.

WHEN (30 min)
6AM 12PM 5PM

WHEN
6PM 12AM 5AM

WHERE - LOCATE ON PLAN

ACTIVITY J MAKE PUZZLES (VOCABULARY)

WHO PARTICIPATES
15 STUDENTS
1 TEACHER

EQUIPMENT NECESSARY

WHEN TWO TIMES A YEAR
6AM 12PM 5PM

WHEN (30)
6PM 12AM 5AM

WHERE - LOCATE ON PLAN

ACTIVITY K ACTION WORK (verbs) run-jump

WHO PARTICIPATES
30 CHILDREN
4 TEACHERS - 1 in CHARGE

EQUIPMENT NECESSARY
TAPE RECORDER - PROPS MADE IN ACTIVITY ROOM - BALLS-JUMP ROPE.

WHEN 1ST SEMESTER
6AM 12PM 5PM
4

WHEN
6PM 12AM 5AM

WHERE - LOCATE ON PLAN

ACTIVITY L. MAKE PROPS FOR ACTION

WHO PARTICIPATES
1 TEACHER

EQUIPMENT NECESSARY

WHEN 60 min.
6AM 12PM 5PM

WHEN
6PM 12AM 5AM

WHERE - LOCATE ON PLAN

Figure 1.

The last page of the questionnaire packet was a sketch of the existing campus plan. Each activity indicated on the preceding pages was given, by the respondent, an arbitrary label (A, B, C, etc.) which was subsequently affixed to the area or zone in which the respective activities occurred.

The organization of the LSSD data for analysis has shown a need for a more efficient means of acquisition. A possibility may be to obtain the information through a structures series of passes, with queries ranging from general to specific activity relationships. The advantages of this iterative procedure over the one pass approach may include: a higher quality of response due to a narrowed format; the elimination of much repetitive or redundant information; and a more efficient initial structuring of information due to the ability to more clearly evaluate inherent relationships as the data graduates from general conceptual levels of organization to specific detailed relationships.

Information Organization for Analysis

Analysis of the collected responses is the crux of the design automation endeavor in the realm of people/activity relationships. Thoroughly documented in the literature is the widely used relationship matrix (1) for the purpose of:

> The development of a hierarchical semilattice subset structure for a group of elements whose organization is defined by non-directed graph. (2)

The ability of the relationship matrix to represent the hierarchic order inherent in people/activity relationships may be examined with respect to Weldon Clark's description of data type requirements (e.g., enumeration, spatial reference, relational, and performance data types). (3) The listing of information horizontally and vertically with the subsequent interations recorded by relating each entry across the diagonal of the matrix is basically limited to Clark's simple "enumeration" (4) data type. This limitation is due to the two-dimensional format restriction imposed by the algorithms currently employed.

Consider the basic elements for vertical spatial allocation of a series of activities applied to a two-dimensional relationship matrix. As shown in Figure 2, four possible locations of activities with respect to grade include: below grade; on grade; above grade; and at roof level. The appropriate vertical location may also be constrained by access requirements: physical access; visual access; sound access; and light access. Finally consider the times of possible accessibility in choosing the most appropriate location of each activity.

Figure 3 represents an attempt to structure the above elements into a square (MxM) matrix. The final result is a combination of two MxN matrices:

1) ACTIVITIES interacted with the most appropriate VERTICAL LOCATION; and

2) ACTIVITIES interacted with TIMES of probable accessibility.

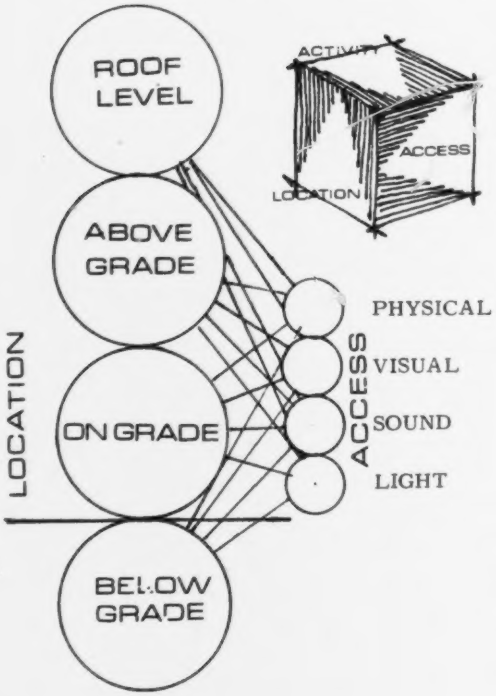


Figure 2.

This organization does not provide for numerical interaction across the diagonal within the ACTIVITY section; within the LOCATION section; or within the TIME section, e.g.:

ACTIVITY : ACTIVITY
LOCATION: LOCATION
LOCATION: TIME; or
TIME : TIME

This type of application severely limits the probability function within many algorithms employing the relationship matrix, to a small number of probable interactions (M-N) as opposed to the larger numerical potential (M), in determining set-element allocation. The more complex data types could conceivably be applied to a relationship matrix if a third dimension was included, as proposed by Milne in his discussion of a "multi-layered" matrix. (5)

The reader, at this point, is directed to

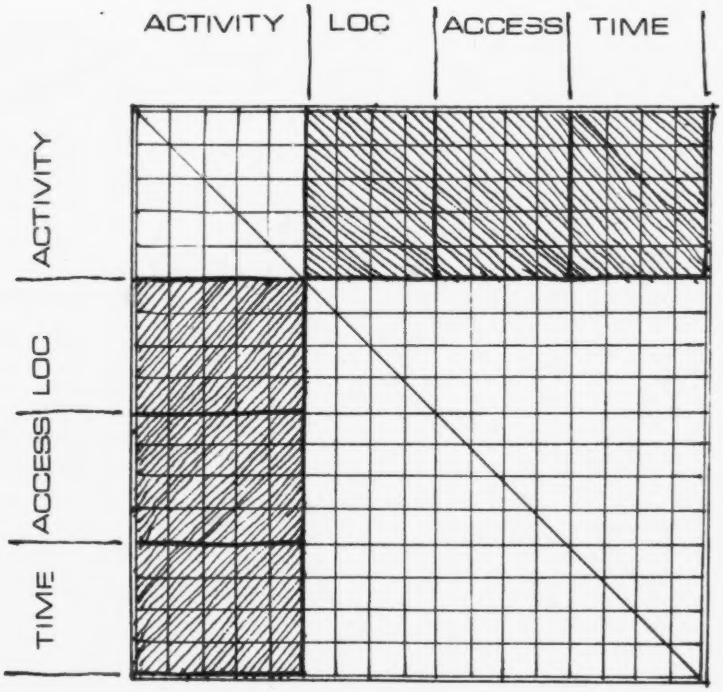


Figure 3.

William C. McGee's "user-oriented" discussion of file processing and data structure requirements more complex than rectangular arrays. (6)

Tree Representation of Files in RFMS

The variability inherent in the LSSD data can be accommodated as a special kind of directed graph, a tree structure. The data management system utilized for the LSSD study was RFMS, the Remote File Management System (7). The general properties of RFMS, as opposed to other generalized file management systems include:

a) User definition of data structures as opposed to pre-defined data structures to which the user must conform.

b) A variety of data types: numeric, alpha-numeric, and alphabetic data.

c) A non-procedural user language interface that allows, retrieval of output from the system, as opposed to procedural languages that allow the description of algorithms to the system.

In RFMS emphasis is on tree structured data (hierarchical data structures) where nodes (branches) of the tree contain certain attributes which have corresponding values. There exists two types of attributes: attribute/value pairs and repeating group attributes.

a) Attribute/Value Pairs: attributes with values associated directly to them:

Attribute - Name
Value - Mark D. Estes

b) Repeating Group Attributes: a collection of attribute/value pairs, all of which have a common superior node, e.g., repeated values associated with a particular attribute:

Attribute - Address (repeating group)
Attribute - Street
Value - 5700 Cameron

Attribute - City
Value - Austin

Structuring the LSSD Data for RFMS

The definition of the RFMS component structure, e.g., the indication of the hierarchical relationships among the elements of the LSSD data base is shown in Figure 4. Elements one through five in the component definition of the LSSD data describe the people that use the facility, for example:

User - Faculty
Level - Primary
Classification - Prep A
Resident - Non-resident
Sex - Female

The use of multiple components to describe the user allows a range of retrieval capability from general people categories to individuals. The remaining attributes comprising the component definition provide a description of the activities performed with respect to:

WHAT	Process	Supervise
	Activity	Tongue Gymnastics
WHEN	Time	0800 (clock hours)
	Duration	0015 (minutes)
	Day	M T W TH F
	Occurrence	Weekly
WHERE	Zone	026
	Location	Classroom
	Coordinates	X, Y, Z

The activities are further defined by the description of the participants involved for each occurrence of an activity. The participants are described in the same manner as the user, with the number of participants indicated. Also included is a description of resources utilized, e.g., artifacts and materials.

```
DEFINE!
NEW DATA BASE LSSD!
<1> USER
<2> LEVEL
<3> CLASSIFICATION
<4> RESIDENCE
<5> SEX
<6> PROCESSES
   <60> PROCESS
   <61> ACTIVITY
   <62> TIME
   <63> DURATION
   <64> DAY
   <65> OCCURRENCE
   <66> ZONE
   <67> PARTICIPANTS
      <670> PARTICIPANT
      <671> PARTICIPANT LEVEL
      <672> PARTICIPANT CLASSIFICATION
      <673> NUMBER
      <674> PARTICIPANT PROCESS
   <68> RESOURCES
      <680> ARTIFACT
      <681> MATERIAL
      <682> ENVIRONMENT
   <69> LOCATION
   <70> COORDINATES
      <700> X
      <701> Y
      <702> Z
```

Figure 4.

The Application of RFMS to the LSSD Data

Once a file has been recorded on secondary storage (e.g., cards, paper tape, disk or drum storage) it may be subjected to a variety of file operations. One such operation transforms the information retrieved into input to an algorithm that analyzes the people/activity interaction. Figure 5 diagrams the potential intensity of interaction between two people (groups) with respect to time and space.

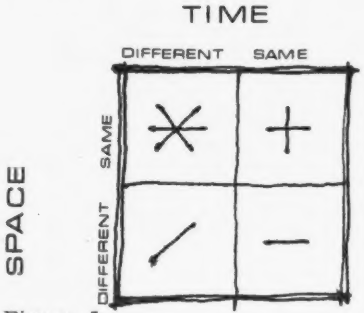


Figure 5.

Two people (groups) who share the same space at the same time have a greater potential interaction than two who share the same space at different times, etc. The concentration of symbols representing high interaction potentials over a defined period of time indicates activity nodes within the physical facility.

Limitations experienced in the range of retrieval queries attempted within the LSSD data base were due to the application of a generalized system to specialized problem areas. One such limitation involved a query concerning the frequency of the occurrence of a specific activity constrained by certain conditions (time, location, etc.). The request "PRINT COUNTED ZONE;" will return the number of times each value associated with the attribute, ZONE, was found in the data base, as shown in Figure 6.

```
*PRINT COUNTED ZONE;
 ...REQUEST ACCEPTED
    <ZONE> 006
   .FREQUENCY COUNT.        2.0000
    <ZONE> 007
   .FREQUENCY COUNT.        17.000
    <ZONE> 008
   .FREQUENCY COUNT.        4.0000
    <ZONE> 026
   .FREQUENCY COUNT.        55.000
    <ZONE> 030
   .FREQUENCY COUNT.        13.000
```

Figure 6.

The frequency count for ZONE 026 was relatively high. The request, "PRINT ACTIVITY WHERE ZONE EQ 026;" as shown in Figure 7, lists each occurrence of the activities in ZONE 026.

```
*PRINT ACTIVITY WHERE ZONE EQ 026;
 ...REQUEST ACCEPTED
 ...WHERE CLAUSE PROCESSING IS COMPLETE
    <ACTIVITY> FILMS
    <ACTIVITY> SPEECH
    <ACTIVITY> CONFERENCE
    <ACTIVITY> CONFERENCE
    <ACTIVITY> CONFERENCE
    <ACTIVITY> SPEECH
    <ACTIVITY> INSTRUCTION
    <ACTIVITY> INSTRUCTION
```

Figure 7.

The request, "PRINT COUNT ACTIVITY WHERE ZONE EQ 026;" (Figure 8) is the sum of the activities listed in the previous request.

```
*PRINT COUNT ACTIVITY WHERE ZONE EQ 026;
 ...REQUEST ACCEPTED
 ...WHERE CLAUSE PROCESSING IS COMPLETE
COUNT <ACTIVITY>          55.0000000
```

Figure 8.

The more desirable request in an interactive mode would output each activity only one time with the number of times (count) each activity met the condition specified by the where clause, e.g.,

```
*PRINT COUNT WHERE ZONE EQ 026;
   .ACTIVITY.    FILMS
 .FREQUENCY COUNT.              1.000
   .ACTIVITY.    SPEECH
 .FREQUENCY COUNT.              2.000
   .ACTIVITY.    CONFERENCE
 .FREQUENCY COUNT.              3.000
   .ACTIVITY.    INSTRUCTION
 .FREQUENCY COUNT.              2.000
```

Currently, problems similar to this are being documented in an effort to revise the retrieval module of RFMS. A similar documentation describing the difficulties with the loader module (RFMS input to build a data base) with a working alternative was accepted for system implementation.

The potential interface between RFMS and existing spatial allocation algorithms; the application of these techniques to a range of problem types with varying degrees of scale and complexity; and the success and pitfalls experienced with RFMS in a practical working situation are current areas of investigation.

The ability of a consistent nucleus of information that will respond dynamically to new input and interactively provide feedback with respect to heuristic investigations enables the designer to support "intuitive" decisions and more accurately explore the ramifications of these decisions.

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COMPUCON: COMPUTER AIDED INFORMATION SYSTEM FOR COMPONENT CONSTRUCTION

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Abstract

COMPUCON is developed to compare alternative design configurations utilizing both graphic and alphanumeric data. Three dimensional representations for component assemblies are generated in conjunction with pertinent physical, performance, and cost data. A demonstration of COMPUCONS' application to a design situation is illustrated. Three configurations are developed and graphically compared assisting in the evaluation of tradeoffs between the built form, costs, and attributes.

Need for Design Aids

In the problem solving situation existing in the industrialized building process, three factors of importance to the design implementation become apparent. These are (1) the necessity for greater choice and individuality for the users of industrially produced building; (2) better utilization of information available to the designer; and (3) greater accuracy in cost estimation at an earlier stage in the design process.

Need for Greater User Choice and Individual Expression

With the ever increasing levels of industrialization in the built environment, resistance from the ultimate user toward further increase in mass production is becoming evident. People feel industrialized construction can lead to deprivation of personal expression. They feel that control over their lives must be returned and not continue to be directed by the technology meant to serve them.

> People *feel* that standardization in buildings is a high price to pay; they are afraid of the possibility of curtain-wall monotony. And to all of the arguments that this is not *necessarily* the inevitable result of mass-produced component systems, it can only be said that while this is theoretically true, the results that we see around us give us some reasons to doubt that it cannot happen. The thousands upon thousands of acres of faceless subdivision housing more than adequately attest to what happens when the concept of mass-production is put to the practical test in the real world.
>
> The mood of our times is rebellion against the mass-production syndrome and all the things that it implies: the ticky-tacky house, the thousands of people dressed alike driving the same freeway in the same cars to the same kinds of jobs day after mass-produced day. It is a rebellion in which man, after having placed control of his life in the hands of technology for more than a thousand years, now asks for that control to be handed back. (1)

This trend toward standardization impedes the ability to create an adequate and appealing environment. A tool is needed to provide a method to attain greater choice in the design and selection of individual components, assemblies, and living units. Greater variety in constituting alternative configurations could eventually lead to more diversity, in turn facilitating a multitude of experiences essential to the question of personal and community identity for users of industrially produced building. Ultimately repetition must allow greater sensory stimulation, not deprivation, in the creation of our built environment. It must provide a feeling of identity, emotional excitement, variation, and variety along with the existing criteria of cost and quality control.

Better Utilization of Information

With modern technological developments the designer is faced with a staggering variety of materials and techniques. The potentialities of these developments are little understood. There is little time for exploring properties and attributes. They increase in complexity while visual or esthetic properties become even more subtle and less explored. Under these circumstances the designer suffers; becoming progressively inundated with new technological "breakthroughs" and at the same time, less aware of user requirements and limitations. He has time only to skim the majority of the new information constantly flooding his practice; much is discarded, the balance being filed away, seldom if ever drawn on. Less able to comprehend the complexities of technological achievements his designs become more vulnerable to pressures of time and manufacturers' demands. Ultimately he has to resort to gross simplification and his intuitive interpretation of what products and processes are applicable to his present need.

Cost Estimating

A factor presenting an equal if not greater concern to the designer is cost estimation at an early phase in the design process. Most decisions generated throughout the design ultimately depend upon initial cost predictions. Difficulty in predicting these costs constrict the development of realistic alternatives, ultimately retarding innovative design.

In the initial design phases very little "hard" data is available to the designer. As the design progresses from abstract concepts, more refined levels of detail are evolved. As this process develops the resulting data becomes more accurate and cost predictions more refined. With the myriad of parts and components in a building the effects produced by a single change, let alone the multitude of changes possible in materials or processes become difficult to comprehend. The need then, is for an estimating aid which will place the designer in a better position to judge the effect of his decision on the total building. A tool possessing these attributes would allow components to be interchanged, providing the ability to determine the most appropriate application while presenting cost comparisons between components, living units, and building alternatives.

Attributes of a Design and Cost Control Tool

On the basis of the preceding, a tool to provide even a partial solution must incorporate the following attributes:

-Organize verbal/visual data in a structure which is easily and quickly updated and expanded.

-Increase the amount of relevant information getting to, and used at an early stage in the design process and at levels of detail suitable to that stage in the process.

-Provide a cataloging system to classify components at specific levels of detail and thereby increasing comprehension of individual attributes.

-Provide for a relationship of costs to alternative geometrical configurations, providing greater rationale for choice between alternatives. The greater the number of permutations that may be carried out the better chance to conceive a more rational solution.

-Allow the majority of time spent in the design stage to be used in the development of parallel alternatives, not on the synthesis of a single solution - parallel alternatives should not be developed to detailed levels until convergence toward one solution is apparent.

> There is a need for the generation of alternative configurations of space units so that he may select from valic alternatives. It is worth pointing out here that psychology and economy are against the designers generating a full set of valid alternatives - once he has gone through the labor of generating one, he falls in love with the infant and is then not eager to find other ones. (2)

Applicability of the Computer

The complexity of construction processes, the repetitive nature of industrialized building, the array of design alternatives, coupled with the limited experience and available information utilized in the design process; these all tend to cause the final solution to fall short of the designer's expectations. The designer predicts and ultimately conceives the built form through mental visualization of the spatial design. The unfortunate fact is that these predictions are entirely dependent on randomly accessed material stored in the designer's memory. Because of limitations placed on his mental capacity to store and utilize the vast quantities of information available, his design creativity and decision making ability are impaired. He must therefore, seek extensions to this mental storehouse. The computer can most fully serve this extension of man's capability through provision of an increased capacity storehouse of information. It can facilitate better access to and use of graphic/non-graphic data allowing more thorough searches for appropriate components and configurations.

Other complications inherent to the building industry are price fluctuations and constantly changing construction factors. One solution is a factor which is commonly used today, human judgment. The designer must have the freedom to override the system and exercise his own initiative to input specialized cost data.

> ...the estimation process appears to be inherently dependent on human judgment, and it is concerning just such problems that judgment is much used in the human estimating process. Therefore, a likely solution is to treat the problems on manual override... in the form of manual insertion of unit costs or cost indexex. (3)

The concepts of continuous cost monitoring throughout the design process, constant updating of cost data, current cost figures from accurate sources, and provision for human judgment, can be designed within the framework of computing software systems, allowing accurate cost estimation throughout the design stage. Hopefully this can be accomplished, allowing the designer to maintain his creative expression and freedom while being guided by the computer in handling and comparing alternatives of components and assemblies. With this form of partnership, a more valid rationale for design decisions might be established enabling the designer to spend more time in the design phase and less carrying out the tedious and time consuming tasks of information retrieval.

'Heathkit' Approach to the Development of COMPUCON

The 'Heathkit' approach is based on the principle of combining priviously developed programs which have been employed in generalized problem solving applications. (4) These programs are adapted to meet new and specific needs, in this case an architectural data management system. The rationale for this focuses on the concept that to write complex programs such as utilized in COMPUCON, several man-years of computer programming would be required. Krauss and Myer inadvertently present the concept of a 'Heathkit' approach:

> The dominant characteristic of the system and its chief value to the user would be as an organizer of information. The system would not be dominated by any large, single operation; rather, it would contain a large number of small operations tying together several bodies of data. (5)

The idea of uniting differing programs and data structures presented by Krauss and Myer unconsciously voices the proposal that a single integrated data base might not be the 'end-all' solution for an architectural information system. Instead, they propose finding a method to link separate data bodies; the result being that fewer architectural information systems presently in existence would have to be revised or replaced.

A necessary goal in using the 'Heathkit' approach is minimizing of programming. This compensates for duplication or inefficiency resulting when uniting the selected segments. The majority of alterations will occur in input and output format if a compatible assemblage is to be created. One of the greatest attributes of this approach can be illustrated by referencing prior works on which COMPUCON is based. Often, these were developed utilizing large personnel and monetary allocations. In some cases, upon completion of the study, only limited acceptance and use was found and the programs were shelved. Through utilization of the 'Heathkit' approach smaller allocations have to be expended and if the study must be shelved fewer resources will be lost.

The 'Heathkit' approach depicts the use of a basic structure or "circuit board" into which a series of components are plugged. Each of these component members, originally separate generalized problem-solving programs, are intermeshed for the express purpose of realizing one or more specialized requirements within the total system. These component members can be drawn from many diverse disciplines to serve as functioning entities of the total system package; the greatest requirement being the understanding of their data structure so modifications can be made for inter-program compatibility. An integrated data structure can thereby link all the programs without the necessity of totally restructuring individual data bases. In COMPUCON two data bases, one graphic and one alphanumeric, are linked so that both data bases can be left virtually intact. COMPUCON utilizes a graphic three-point perspective program as the "circuit board", the central controlling communication package. Into this are plugged graphic projection routines, data manipulation programs and the two primary segments; the data retrieval program and a cost estimating program. The "circuit board" is still flexible enough to add additional programs to further extend its value to the designer.

a) Information Retrieval Description - The information retrieval segment allows rapid construction of data management programs through the use of a special series of sub-routines and is designed to be 'user oriented' with only a minimum number of commands required for operation. The system diverges from standard information retrieval operations in one important concept. This is the approach taken to list structures and list processing languages. There are several disadvantages which must be considered in any application of list processing. There is a built-in generality which often cannot be utilized in more than a few applications. Increases in both processing time and storage requirements, as well exemplified in the list structure of the graphic segment of COMPUCON, can severely handicap a program when limited to a small capacity machine. The reduction of essential main storage can mean the difference between a functioning retrieval system or no system at all.

With this program two levels of storage are required; level 0, or word addressable core memory, and level 1, fast access disc storage. Data is called into level 0 only as required by the program. Data resides in level 1 storage in two manners; as pages which are brought to level 0 as required, and as units which can be

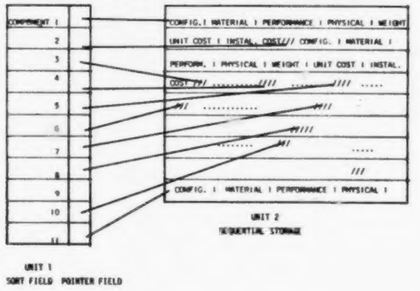
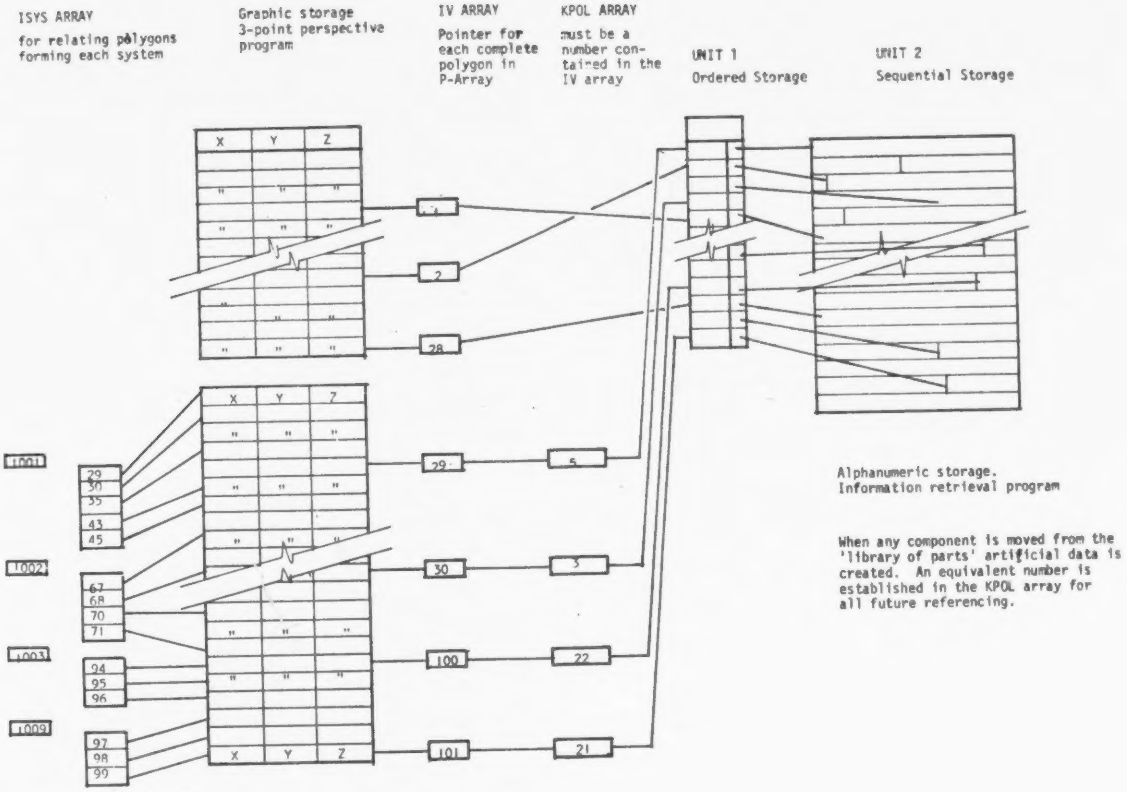

COMPONENT 1
2
3
4
5
6
7
8
9
10
11
CONFIG. | MATERIAL | PERFORMANCE | PHYSICAL | WEIGHT
UNIT COST | INSTAL. COST/// CONFIG. | MATERIAL |
PERFORM. | PHYSICAL | WEIGHT | UNIT COST | INSTAL.
COST /// ..../// ..../// .....
/// .... ////
////
.... /// .....
///
CONFIG. | MATERIAL | PERFORMANCE | PHYSICAL |
UNIT 2
SEQUENTIAL STORAGE
UNIT 1
SORT FIELD POINTER FIELD

Figure 1.


ISYS ARRAY
for relating polygons forming each system
Graphic storage 3-point perspective program
IV ARRAY
Pointer for each complete polygon in P-Array
KPOL ARRAY
must be a number contained in the IV array
UNIT 1
Ordered Storage
UNIT 2
Sequential Storage
X Y Z
1
2
28
29
30
100
101
5
3
22
21
1001
1002
1003
1009
29
30
35
43
45
67
68
70
71
94
95
96
97
98
99
Alphanumeric storage.
Information retrieval program

When any component is moved from the 'library of parts' artificial data is created. An equivalent number is established in the KPOL array for all future referencing.

Figure 2.

manipulated and created as needed. Two types of units are available, ordered storage units with fixed format entries (or fields) and sequential storage units containing variable length character strings. Each 'page' in level 1 sequential storage consists of a descriptor along with the alphanumeric information which is retrieved through the use of the associated entry in ordered storage as noted in Figure 1. By use of this type of structure complex messages may be built up, structured by the links or pointers connecting the storage units with one another. While list processing languages and list structures provide one method in the organization of data, the system outlined provides a much more powerful package for retrieving data without consuming large amounts of core storage locations and similarly large amounts of processing time.

b) Data Structure - The graphic segment of COMPUCON contains the main program which in turn calls up eight sub-routines to carry out specialized data manipulation and graphic projection. The alphanumeric initializing and data storage routines are called from this program. The retrieval program is called as graphic data is manipulated. It contains a series of specific constraints have been fulfilled. These are met through utilization of certain specialized user oriented commands.

The graphic data consists of closed geometrical configurations (polygons). Each point in a polygon is described by a unique set of x, y, z coordinates which are stored in the point or P-array. The IV array in turn keeps track of the last point of each polygon thereby becoming the controlling factor in determining many operations, especially communication between the graphic and retrieval programs. The program numbers each polygon sequentially and these are called for manipulative purposes by that assigned number, more accurately, the IV array pointer. The first components to be read into the program are the 'library of parts'. They are numbered and henceforth referenced to by this number. The retrieval program then uses these same numbers to locate the alphanumeric information required for use in describing that component. (See Figure 2.) The alphanumeric data for each of the graphic elements is stored in the sequential storage unit, being drawn or 'paged' from the ordered storage unit. This unit has pointers attached to each component

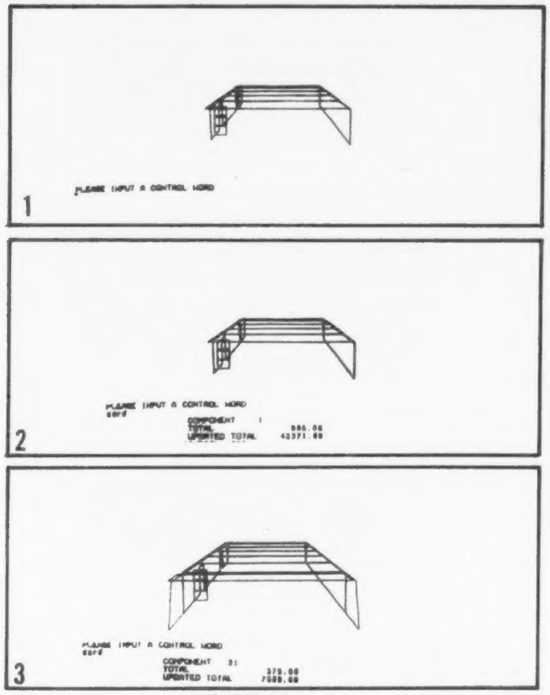

1
PLEASE INPUT A CONTROL WORD
2
PLEASE INPUT A CONTROL WORD
COMPONENT
TOTAL
UPDATED TOTAL
3
PLEASE INPUT A CONTROL WORD
COMPONENT
TOTAL
UPDATED TOTAL

Figure 3a. UNIT 1 alternatives 1, 2, 3

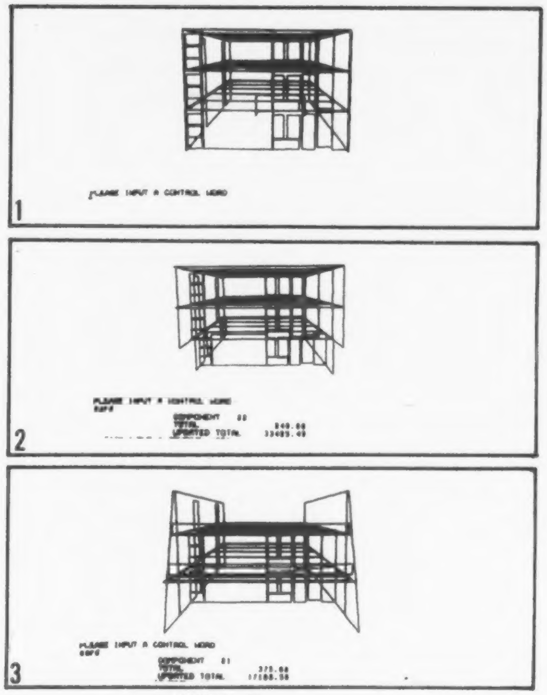

1
PLEASE INPUT A CONTROL WORD
2
PLEASE INPUT A CONTROL WORD
COMPONENT
TOTAL
UPDATED TOTAL
3
PLEASE INPUT A CONTROL WORD
COMPONENT
TOTAL
UPDATED TOTAL

Figure 3b. UNIT 3

indicating the correct location of the alphanumeric criteria for each component. The ordered storage unit has a related pointer from the IV array which provides the key link between the graphic and alphanumeric data storage files. The number of ordered and sequential units may be increased so that each component classification may be separated into individual data files. This is necessitated when a large and complex 'library of parts' is created. Alphanumeric data for each component is contained on a single card in specified fields or locations. Data categories include: component number, utilization, material, dimensional criteria, performance criteria, (U-factor, fire rating), weight, unit price, and installed cost. The choice of data presented here is meant to represent only a sample of possible categories which might be desired by a potential user of COMPUCON.

Application of COMPUCON

To validate the use of COMPUCON in a design situation a hypothetical panel system is created and 28 basic components are stored in the 'library of parts'. These components consist of incrementally sized floor and wall panels and a variety of exterior infill components. They are presented in two manners; a graphic-alphanumeric representation on the CRT, and a listing on the line printer including all physical, performance and cost data pertinent to each component. The graphic representations are created by machine digitizing scale drawings of the components. This establishes a three dimensional coordinate system for utilization in COMPUCON's graphic segment. Each component is stored in the 'library of parts' and drawn on through the series of user oriented commands. To speed up the process of moving individual components to their final locations the SYS command allows the creation of systems of components. In this demonstration systems are made up of wall and floor components of varying configurations. This is accomplished by placing the wall and floor elements for the initial living unit, then declaring these elements a system (SYS). This grouping can then be moved as a single entity to any other desired location with only a single command. It may be used any number of times to create identical units, the only limitation being the storage capacity of the machine. The program is designed so that all alphanumeric data is displayed and printed for each component when each system is moved. This provides a continuously updated cost figure current with the design buildup. Based on these 28 components, a standard floor plan was selected from which three alternative configurations are generated. The single floor plan illustrates the possible

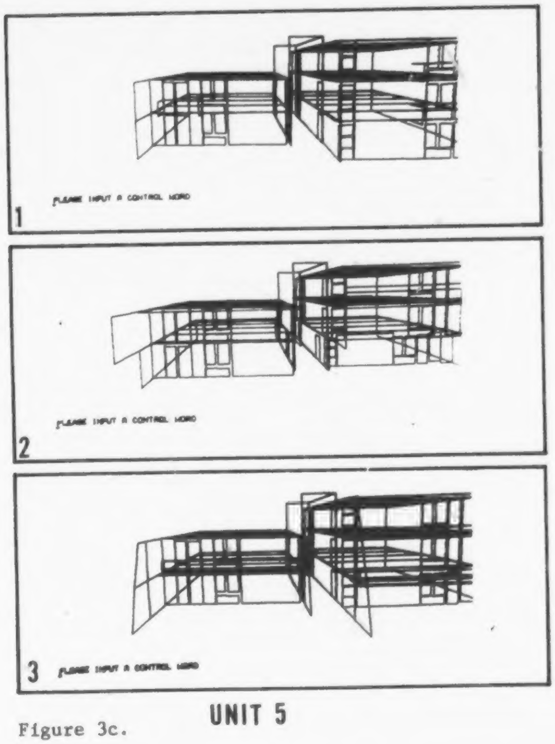

1
PLEASE INPUT A CONTROL WORD
2
PLEASE INPUT A CONTROL WORD
3
PLEASE INPUT A CONTROL WORD
UNIT 5

Figure 3c.

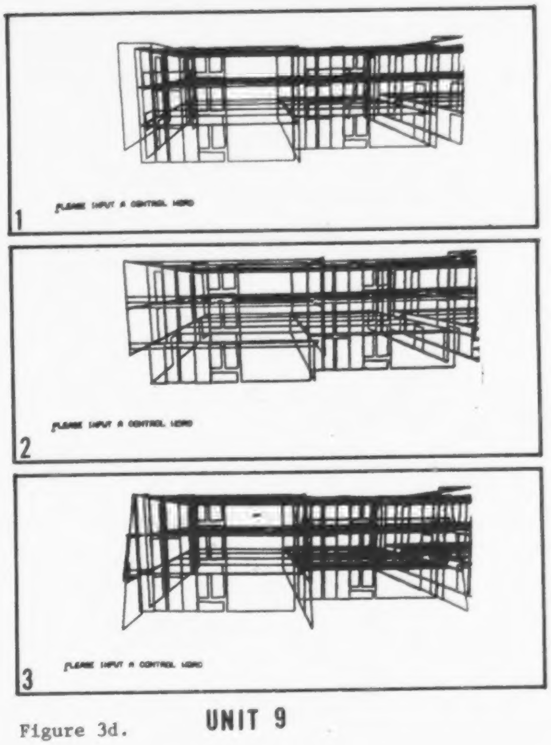

1
PLEASE INPUT A CONTROL WORD
2
PLEASE INPUT A CONTROL WORD
3
PLEASE INPUT A CONTROL WORD
UNIT 9

Figure 3d.

variations between alternatives in their final form. The plan calls for a three-story residential development consisting of 9 individual living units. Differing infill units, wall elements, and balcony arrangements are utilized. The graphic presentations on the CRT can be compared one with the other and in turn with cost print-outs as demonstrated in the series of illustrations in Figures 3a, b, c, d.

In this presentation the 'library of parts' consists of only 28 components, but has the capacity to be expanded well beyond this number. Only structural and infill sub-systems have been generated where a greater repertoire of sub-systems would present a much more comprehensive study of the complete building. Extrapolating on the simplistic nature of these alternatives, it may be seen that a great variety of forms might be generated depending on the time and the level of desired detail. Major configurations or systems may be interchanged to provide large scale comparisons while at a lesser scale individual components can be substituted to compare subtle design changes. A client may determine what most suits his visual taste modified by the print-out of cost data; a more rational method to determine the design configuration best meeting the needs and budget of the client.

Success of 'Heathkit' Concept

The amount of programming necessary to unite the segments and provide cost estimating routines is minimal in comparison to the necessary requirements to develop a similar program from the outset. The concept demonstrates that an individual with limited programming experience can combine programs in a manner allowing the construction of a powerful tool tailored to exacting needs. The greatest portion of time spent in combining the programs was not in actual programming, but in understanding program operations and data structures to determine essential modifications.

COMPUCON is extremely fast. At times it is difficult to adjust to the rapidity of display. More time must be permitted so the user can comprehend changes as they occur in the building design. In addition, many other information categories could be added to assist the designer but this is best left to the users individual needs. The total graphic and alphanumeric output provides an additional determinate for justification of the final built form.

Attributes of COMPUCON

An attribute of significant merit is the utilization of COMPUCON as a communications device

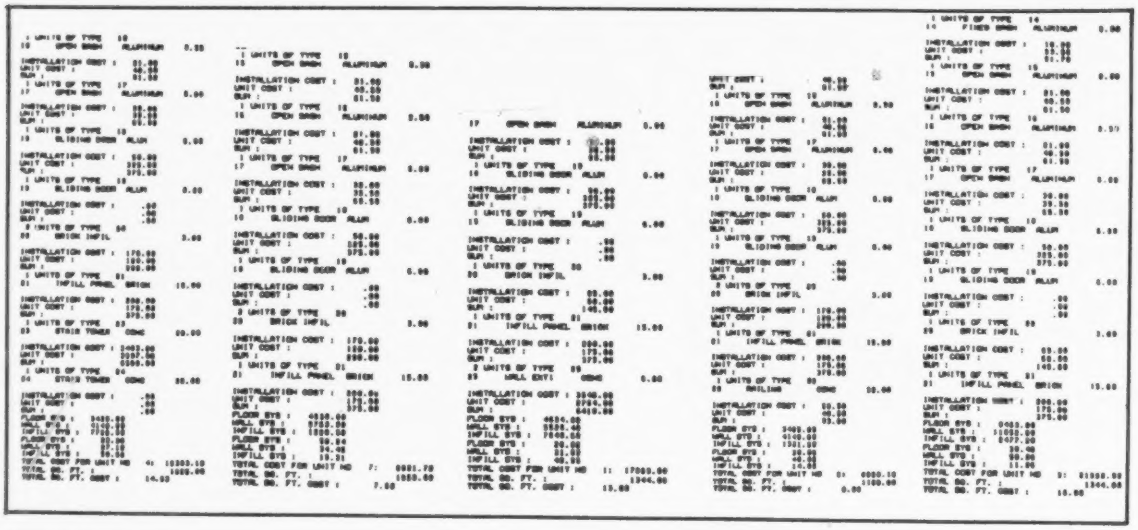


Figure 4.

between designer, client and user. These individuals can watch alternatives being generated on the CRT, input their own suggestions observing design changes and modifications in real time.

> ...the client must (a) play some part by generating information during the design process, and (b) have an opportunity to do this fairly often, to counteract the inertia attached to drawings which will prevent his views from being taken into account. It is clear that constant monitoring by consultants, as by clients, is necessary if an unprofitable line of working is to be checked early. (6)

The tool provides a method enabling the designer, the client and most importantly the user to work together in the creation of more competent designs.

In addition to the aforementioned, COMPUCON has several other attributes:

a) Cataloging and Cost Estimating System. Besides providing the possibility of a communications device, COMPUCON is an excellent cataloguing tool, keeping track of individual components, their assembly sequences, and their integration in sub-assemblies.

b) Comparison of Alternatives. COMPUCON provides a fast method to compare alternatives in the limited amount of time available in the design process. This comparison of alternative design configurations or component choices can occur in several fashions:

-physical criteria can be compared with cost and performance criteria. (Figure 4.)

-components may be interchanged in an existing configuration comparing appropriate physical and performance criteria with aesthetic treatments.

-cost comparisons between alternative configurations may be made to determine those within project cost limitations.

-trade-offs between aesthetic considerations, costs, and performance criteria may be determined and evaluated within the overall design.

c) Graphic Sequences. On completion of the buildup, the DLET command allows deletion of unnecessary graphic representations thereby clarifying the image on the CRT. With the incremental PLOT and MOVE commands, animated sequences of movement about the structure may be prepared. These allow the designer and user to view the final form from any position in static or dynamic presentation in a fast and accurate manner. Figure 5 demonstrates this capability.

In addition, a uniformly detailed basis for cost estimating is available throughout the life of the design project. The designer can input components for a current project, comparing progress and cost of the real construction project with the computer model. This will place him in a more reliable position to determine where cost differentials occur and possible reasons for them, hopefully resulting in the ability to utilize this knowledge in more accurate predictions of future design.

Limitations of COMPUCON

One of the greatest problems has been the storage capacity of the computing system, primarily due to the large block of core used for graphic data. This necessitated the simplified graphic representations apparent in the illustrations. Further complicating this was the size of the

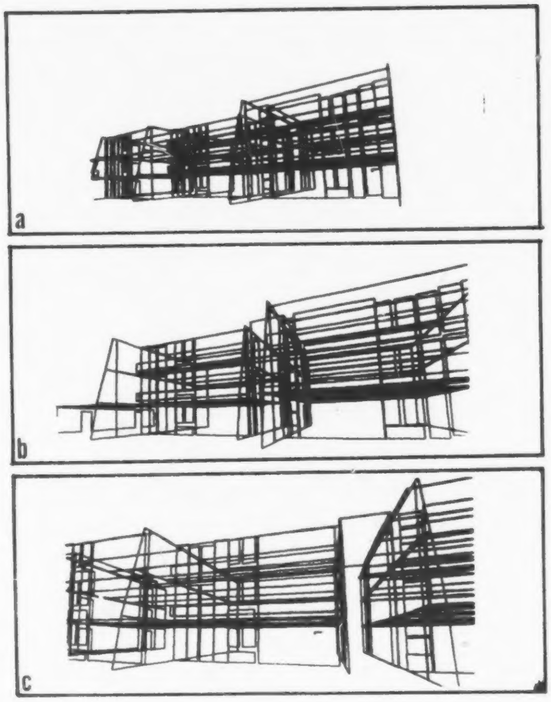


Figure 5.

individual programs, and redundancy in the data bases due to duplication in the establishment of separate data bases. This would not occur had this been written as a single entity but the trade-offs between extra storage locations and the number of resources utilized justify this approach.

The most obvious limitation is positioning of graphic elements on the CRT. No direct method is available at present to move components from the 'library of parts' without knowing the coordinates of the component and the position to which it is being moved. A partial solution was implemented as illustrated in Figure 6 using a grid system with predetermined spatial coordinates. Locations are more easily established, enabling faster and more accurate placement of components. This problem occurred as equipment with light-pen capacity has only recently been available and little other than standard software has been developed.

Proposals for Future Developments of COMPUCON

After implementation of the retrieval program it became apparent that the graphic storage, or P-array, which occupies such a large block of core could be located in disc storage. This would leave main core free for more elaborate computations. Another method to achieve similar results is utilization of the 'overlay loader', part of the operating system developed by Xerox Data Systems for the Sigma 5 on which this program is implemented. The main program in COMPUCON is held in residence (main core) while sub-routines are kept on disc, called into core only when required for manipulative purposes. If these are implemented, more detailed representations and larger scale projects could be undertaken incorporating all of the sub-systems necessary for a complete design.

A second proposal is in essence a reversal of the present COMPUCON structure. The graphic program is subordinated, becoming a sub-routine of the retrieval segment. With this structure the designer, utilizing the same data format, can retrieve components by performance, physical and cost criteria. Components meeting these requirements can be graphically displayed; the designer, client, and user choosing from those presented. This choice could be based on aesthetic appeal as the component already satisfies all other design requirements.

A third proposal utilizes COMPUCON as a data management system to create an effect similar to the 'cut and paste' technique. This existing method entails cutting, classifying, and storing standard details to be used and reused in the assembly of design and working drawings. A similar application is possible using COMPUCON for the storage of component clusters assembled from the 'library of parts'. These combinations can be developed on the CRT then stored on tape. They can then be retrieved as required, displayed, and combined with other assemblies to create the final building or detail, thus replicating the 'cut and paste' technique.

Effect of Computer Applications on Industrialized Building

With the application of computer techniques, the future of industrialized building can be transposed from the existing limited repertoire of mass-produced components to that of totally individual 'one-off' elements. This is already apparent in several highly automated industries today, most notably textiles. One discussion of this trend presents an architectural application:

> It is precisely because of our fixation with a house as an investment that no building salesman has yet had the nerve to take a house apart, to break it into components, coordinates or whatever, and let the buyer do what the fashion trade calls 'mix and match'....Well maybe the result would be no more inspiring than the spec-built efforts we know, but at least it could offer (a) more variety of family space within a

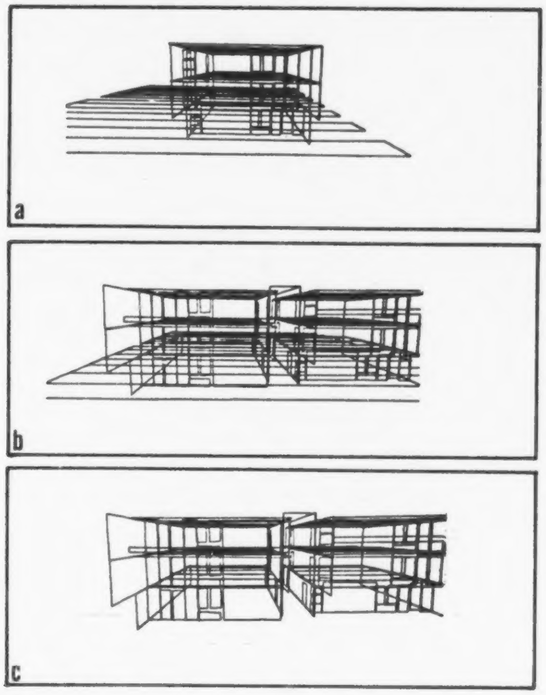


Figure 6.

unified design framework (b) more adaptability to the different character of sites, (c) more potential for true mass production. (7) This illustrates the possibility of 'mixing and matching' components from the 'library of parts', producing complete sub-assemblies which in turn constitute the final built form.

If computer-aided tools can be developed to a level where laymen can sit at a console to choose components for their living units, the stigma of industrialized housing might be eradicated. In this manner mass-production might finally bring more choice to the consuming public. Computer-aided design tools might provide what so many people are demanding; variation and choice of diverse living conditions in an already too standardized environment.

Notes

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(5) op. cit. pp. 105.

(6) Britain, Ministry of Public Buildings and Works, Computer Aided Architectural Design, Part I. ([London]:1969). pp.169.

(7) "Housing", Architectural Review, September 1970. pp. 190.

INFORMATION SYSTEMS FOR ARCHITECTURAL PROGRAMMING

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Introduction

Architects are just beginning to use information management systems to maintain project data bases containing architectural program information. For large or complex projects, such as hospitals, the data base may contain several million entries, even though the program is stored on a room-by-room basis and only a few types of information are recorded for each room. For example, a program for a 15,000 room teaching hospital with 10 data entries per room and an average of 10 characters per entry contains 1.5 million characters. Even for a project of medium complexity, if detailed data is recorded about equipment, furniture, or relationships among work stations, then the data base becomes very large.

Traditional means of manually maintaining large and complex data bases appear increasingly inadequate. By the time the program is collected, reviewed and assembled into a book or a series of charts for client approval, it becomes obsolete. It is difficult to find errors and inconsistencies in the original data. It is difficult to update the program to reflect changes in the client's organization and requirements as design proceeds. It is particularly hard to effectively use the data to aid in design decisions, because manual extraction, tabulation, and analysis of the data is onerous, time-consuming and prone to error. It is a major effort to check the proposed design solution for conformity to the programmed requirements. Thus a computer system becomes essential.

Various approaches to the development of a computer system for managing architectural program data are possible. They include three principal alternatives: custom development of the entire system (1), construction of a system from available subroutines for data base management (2), (3), and adapting an existing generalized information management system to architectural programming. The last approach is currently the most promising for architects because of the need for immediate project use, the limited resources for computer program development, and the inherent complexity of an information management system. In addition, architects lack enough experience in using these systems to be able to design a system better suited to any unique requirements of the architectural design process.

Two of these generalized computer systems for information storage and retrieval, RAMIS and TABLE, are being used by Skidmore, Owings and Merrill for current projects. A comparative study will illustrate some of the differences in approach between them as well as some of the characteristics they share with other information management systems. RAMIS and TABLE will be compared with regard to system concepts, data structure, capability, cost and user convenience. From this comparison, criteria will be formulated and suggestions will be made for the future of design information systems for architects.

The systems are illustrated with examples from current areas of application architectural and interiors programming. However, these information systems are clearly useful for other types of architectural data bases such as hardware, finish or equipment schedules.

Overview of TABLE

TABLE II is an information storage and retrieval subsystem of the Integrated Civil Engineering System developed at the Massachusetts Institute of Technology (4), (5). It originated as a means of maintaining a data base of structural steel section properties for use in the Structural Design Language (STRUDL) (6). It became an independent ICES subsystem and was expanded to include alphabetic and integer data (7), (8). During the past year Skidmore, Owings and Merrill has added some selective inquiry and reporting capabilities to TABLE to use it for architectural programming data.

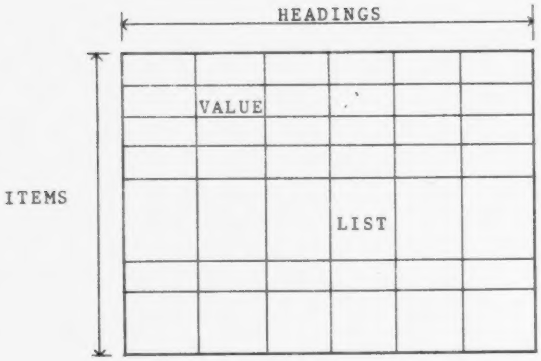


Figure 1. Organization of Basic Table

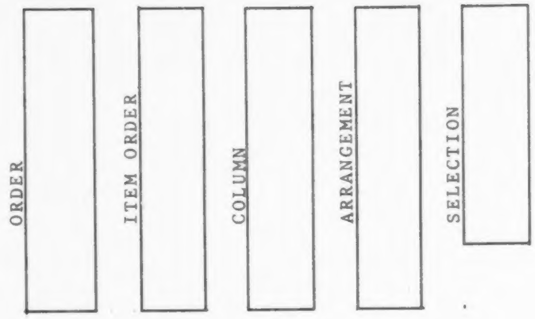


Figure 2. Adjuncts to Basic Table

Conceptually TABLE stores data in a series of tables. Each table is a matrix (Figure 1). The columns of the matrix are called headings, and the rows are called items. At the user's option a cell of the matrix may contain a single value or multiple values (called a list). The user defines the heading names and the type of data each heading may contain - alphabetic, integer, single or double precision. If the cells of a heading are to contain multiple values, the heading is a list heading.

The user may extract information from individual headings of the basic matrix, operate on it, and store it as an adjunct to the table (Figure 2). The additional data, called orderings, include five kinds of extracts: orders, the item order, columns, arrangements, selections. A column contains all the values from a single heading; an order contains values from a heading in ascending or descending order; the item order is an alphabetical ordering of the item names; an arrangement is always with respect to an order and contains values for a second heading in the same sequence as the specified order; a selection contains values from a heading for those items satisfying conditions specified by the user. TABLE automatically deletes all orderings when the basic table is modified, to prevent the user from referring to data which may have been modified. Selections may be only temporary, for a single run, or may be stored by the user along with the other orders.

A table is stored as an indexed file accessed by the item names. Each row is a fixed length record with the list data stored separately, as variable length records. Thus for list headings a pointer to the list data replaces a value in the row of the table. Two records are stored for each ordering: a record of values and a record of pointers to the rows of the original table. These records are indexed by ordering name.

Many tables may be stored in an ICES data set (9). Two data sets are available to the TABLE user, permitting him to work with two versions of a table, or to make modifications to a copy of a table without changing the original data. However, except for the process of transferring data from one table to another, operations are performed upon only one table at a time.

Just as in all ICES systems, TABLE operations are invoked by user commands such as: INITIATE TABLE, ADD DATA, MODIFY TABLE, DELETE TABLE, ORDER TABLE, SELECT FROM TABLE, and PRINT HEADINGS ALL.

Skidmore, Owings and Merrill has used TABLE to manage a data base of architectural programming information for an office and laboratory building for a pharmaceutical manufacturer. The data base contains approximately 3200 items, representing work stations, with 80 headings per item. Since approximately three-eighths of the headings are lists, the total number of values stored is about 275,000, and the total size of the basic tables in the data is approximately 2.2 million characters. Typical output for a portion of the architectural data base containing work station names and number of employees

```
         NAME                           CAT1    QUAN WS   MEN      WOMEN   DATE     INTRVWD  SOM TYPE SKETCH
BIV1     VICE PRESIDENT INTERNATIONAL     02          1     1          0  6- 8-71     OBF      H1       0000
BIV2     SECY VP   INTERNATIONAL          07          1     0          1  6- 8-71     CW       B3       0000
BIVC1    CONSTRUCTION ENGINEERING MGR     04          1     1          0  6- 8-71     MF       F2       0000
BIVC2    SECY CONST ENGINEERING MGR       07          1     0          1  6- 8-71     MF       A3       0000
BIVC3    FILING.LEGAL SIZE                00          1     0          0  6- 8-71     MF       GB5      0000
BIVC4    BLUE PRINT FILES                 00          1     0          0  6- 8-71     MF       SH4      0000
BIVC5    BLUE PRINT CABINET               00          3     0          0  6- 8-71     MF       SG2      M6
BIVC6    BOOKCASE                         00          1     0          0  6- 8-71     MF       KK12     0000
BIVCE1   PROJECT ENGINEER                 05          2     1          0  6- 8-71     MF       SN10     M9
BIVCE2   ASSISTANT PROJECT ENGINEER       06          2     1          0  6- 8-71     MF       SN10     M9
BIVCE3   SECY PROJECT ENGINEERS           07          1     0          1  6- 8-71     MF       A3       0000
BIVCE4   WORK TABLE FOR VIEWING PLANS     00          1     0          0  6- 8-71     MF       A1       0000
BIVD1    DISTRIBUTION MGR                 04          1     1          0  6-15-71     JDO      F2       0000
BIVD2    SECY DISTRIBUTION MANAGER        07          1     0          1  6-16-71     SM       A3       0000
BIVD3    FILING                           00          1     0          0  6-16-71     GD       GB4      0000
BIVD4    XEROX AND STORAGE                00          0     0          0  6-17-71     BIV      SH13     0000
BIVDC1   CUSTOMER SERVICE MANAGER         06          1     1          0  6-17-71     LNB      D3       0000
BIVDC2   SECY ORDER ENTRY                 07          1     0          1  6-17-71     LNB      A3       0000
BIVDC3   ORDER ENTRY CLERKS               07          4     0          1  6-17-71     LNB      A3       0000
BIVDC4   FILING LETTER SIZE               00          1     0          0  6-17-71     LNB      TB3      0000
BIVDC5   STORAGE PRINT OUT BOOKS          00          1     0          0  6-17-71     LNB      CL5      0000
```

Figure 3. Typical TABLE Output: Work Station Codes, Names and Employees

```
         DESCRIPT             DR MK/NO DR RM/RQ CB MK/LF CB RM/RQ SH MK/LF SH RM/RQ FU MK/NO ST MK/NO EQ MK/NO
BIV1     GROUP HANDLES            BX 2     00LK     AL 6     00LK     0000     0000     DE 1     DK 1     0000
         ENGINEERING AND          FT 4       LK                                         CR 2     SL 2     OT 2
         DISTRIBUTION                                                                   CT 1     LO 3

BIV2                              FT 1     00LK     AL 3     00LK     0000     0000     DT 1     SC 1     CE 1
                                  BX 2       LK                                                  SL 1     TE 1
                                  FG 4       LK

BIVC1                             FT 4     00LK     0000     0000     JK 6     00LB     DE 1     DK 1     DC 1
                                  BX 4       LK                                         CH 1     SL 2

BIVC2                             FT 1     00LK     0000     0000     0000     0000     DT 1     SC 1     TE 1
                                  BX 2       LK                                                           DC 1

BIVC3                             FG15     0000     0000     0000     0000     0000     -- 0     -- 0     -- 0

BIVC4    PLAN FILES               FP15     0000     0000     0000     0000     0000     -- 0     -- 0     -- 0

BIVC5                             -- 0      0--     -- 0      0--     -- 0      0--     -- 0     -- 0     -- 0

BIVC6                             0000     0000     0000     0000     KK12     00LB     -- 0     -- 0     -- 0

BIVCE1                            BX 3     0000     0000     0000     0000     0000     DR 1     DK 1     DC 1
                                  FT 1                                                  DE 1     SL 1     OT 1
                                  FP 1

BIVCE2                            BX 3     0000     0000     0000     0000     0000     DR 1     DK 1     DC 1
                                  FT 1                                                  DE 1     SL 1     OT 1
                                  FP 1

BIVCE3                            BX 1     00SS     0000     0000     0000     0000     PT 1     SC 1     TE 1
                                  FT 1
```

Figure 4. Typical TABLE Output with Lists: Storage and Furnishings Data

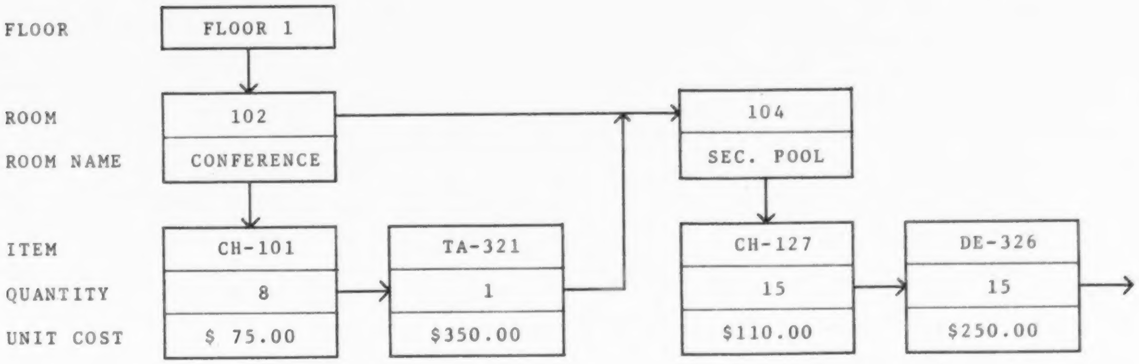


Figure 5. Example of RAMIS Storage Structure

is shown in Figure 3. Descriptive notes and data about requirements for drawers, cabinets, shelves, furniture, seating and equipment are shown in Figure 4 and illustrate the storage of data as lists in TABLE.

A supplementary data base for special mechanical and electrical requirements contains about 1,150 items, 70 headings and 94,000 values, for a total of about .8 million characters.

The architectural data base is segmented into 11 tables, corresponding to major groups within the client's organizational structure. This segmentation reduces the amount of data to be searched in response to user inquiries and helps limit the potential damage to the data base caused by human or computer errors. On the other hand it increases the difficulty of requesting analyses or producing summaries for the project as a whole.

Overview of RAMIS

RAMIS (Rapid Access Management Information System) was developed by Mathematica, Inc., of Princeton, New Jersey, as a self-contained data base management system (10), (11). It is a generalized system which provides the capabilities necessary for creating, maintaining, accessing and reporting from a data base.

Users request information from the system through a command language which is similar to English except that it has some special syntax rules, which can be fairly easily mastered.

Each RAMIS record is composed of data items which the user has named and described. Essentially the descriptions give the system the following information: 1) whether the item is to be used for computation or not, 2) if an item is for computational use, whether it is fixed point or floating point (single or double precision) and the number of characters and decimal point location for display, 3) a synonym or alias for the data item name. A file is a set of fixed-length records of like description and a data base is a set of files. In order to extract information from the data base the user must inform the system which file the information is in, what fields of information he is interested in, and how he desires to have them presented to him.

RAMIS stores records as a tree structure defined by the user in the file description (Figure 5). Duplicate information at one node in the tree is stored only once. This fact is transparent to the user. He sees whole records going into the file and whole records coming out. In most information files this storage scheme can drastically reduce storage requirements and the search time for retrieval and reporting.

In searching for a specific record, knowing something about the data contained in the higher levels of the record can reduce the search. For this respect, a search in RAMIS is analogous to human search. Suppose you are looking for a chair which is unique in a building. If you do not have any idea where it is, you will have to search the entire building. If you know which floor it is on you will only have to search that floor. If you also know the room then you only have to search the room. Likewise, if you wish to sum up the number of items in a room or the cost of items in a room, then you can go directly to the room on the correct floor. In a similar way RAMIS reduces the search for a unique record or a set of records when the user provides information which narrows the search of the tree.

RAMIS interrogation requests are composed of three basic parts. The example below is based on the record structure shown in Figure 5.

```
   SUM QUANTITY IF ITEM IS CH-101
     OR CH-102 BY FLOOR
```

The first part (SUM QUANTITY) is the verb phrase which specifies the action the system is to take with the record it retrieves. In the above example, the word SUM directs the system to add the values for QUANTITY it finds in each record. The second part is the screen or conditional phrase starting with the word IF. This phrase informs the system that only those records which pass the screen (in this case CH-101 or CH-102) should be retrieved and included in the final report. In the third part (BY FLOOR), the system is informed how to group the records which are retrieved. For the example, the total quantity of items CH-101 and CH-102 will be summed for each floor.

In RAMIS the permissible verbs are SUM, WRITE, PRINT, LIST, and COUNT. Other verb phrase operations are HOLD (hold a report as a temporary file), STORE (temporarily in core), SAVE (on an external file), SUB-TOTAL, COLUMN-TOTAL, and ROW-TOTAL. The verbs may act upon data fields in the record or on operations performed on these fields. Examples of these operations are to extract the minimum, maximum or average value for a field.

In addition to these capabilities, there are a number of other operations and features which may be executed at retrieval time to give the user a great amount of flexibility in retrieving and reporting information. Output may be presented in the form of graphs or histograms (12). Many of these features are documented in the tables which appear in the following section.

As well as retrieval, screening and report preparation, RAMIS handles the standard functions of maintaining a data base. These functions are file definition, input, selective input, selective and global updates, deletion of individual records, and creation of temporary or permanent files which are extracts of a RAMIS file.

Three interfaces are provided which expand the standard capabilities of RAMIS to handle unique requirements for input, updating, and reporting. A user may direct the system to use his own FORTRAN or COBOL routines for any of these three functions (13).

Skidmore, Owings and Merrill is using RAMIS to manage inventories of interior furnishings and equipment for a variety of building types, and inventories of required and existing spaces for a large teaching hospital. One project data base for furnishings contains approximately 35,000 items, with 15 fields per item. The total size of the basic files in the data base is approximately 1.5 million characters, representing over 4.5 million characters of logical records.

General Comparison of RAMIS and TABLE

Some of the principal characteristics of RAMIS and TABLE are summarized in the tables below. Table 1 shows their respective capacities for information storage and report generation. Table 2 shows various operational and functional capabilities.

With respect to the computer system environment within which they operate, RAMIS and TABLE are both available for batch or remote processing under OS/360. RAMIS is also available for time-shared use under a version of CMS for the IBM 360. RAMIS is proprietary. The license fees or royalties include user support and program maintenance as well as continuing improvements and extensions. TABLE and ICES are generally in the public domain, except for proprietary modifications, such as the extensions to TABLE described here. Except for these proprietary versions, however, there is no continuing ICES user support or program maintenance.

Both systems are relatively efficient in their approach to storage. If the records can be organized hierarchically so that much duplicated data occurs at the upper levels, then RAMIS requires less storage. Otherwise there will not be significant savings in storage over

	RAMIS	TABLE
Maximum Size of Data Base	(1)	(1)
Maximum Size of File	(1)	(1)
Maximum Number of Fields Per File	64	Unlimited
Maximum Number of Characters Per Record	480	Unlimited
Maximum Number of Records Per File	Unlimited	Unlimited
Maximum Number of Levels (storage)	23	2
Maximum Records in One Report Sorted	3000+	Unlimited
Maximum Records in One Report Unsorted	Unlimited	Unlimited
Number of Temporary Data Fields Per Report	10 (2)	0
Number of File Descriptions Active at One Time	2	1
Number of Files Active at One Time	1 (3)	1 (4)

Notes
1. Unlimited except by operating environment.
2. The total number of temporary and permanent fields cannot exceed 64.
3. Data from several files may be merged into a single report.
4. Also TRANSFER capability and user access to 2 copies of a file.

Table 1. Capacity Characteristics of RAMIS and TABLE

TABLE. For variable numbers of values for a field, the TABLE list structure is likely to be more efficient than RAMIS, especially if there is a wide variation in the amount of variable data from record to record.

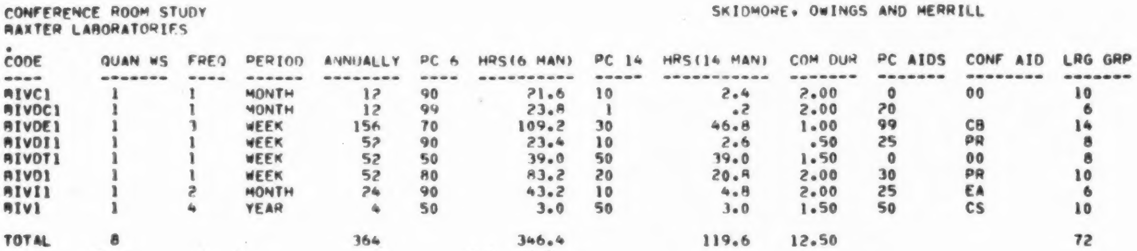
Costs are difficult to compare, since they depend on the pricing policies of individual service bureaus as well as differences in computing efficiency among difficult hardware configurations. Time-sharing is still considerably more expensive than batch processing; except for small data bases, partial use of batch processing will probably be required for economical information processing.

RAMIS provides greater flexibility of report generation and places a greater variety of operations at the user's disposal. Figure 6, a tabulation of one department's annual conference room requirements, would be impossible to produce in TABLE. But this additional power and flexibility increase the learning time required to effectively put them to use. The straightforward storage scheme of TABLE is easier to understand than the more complex hierarchial scheme of RAMIS. Modeling a series of fields with variable number of values can be tricky in RAMIS.

Specific Comparison of RAMIS and TABLE

Using a portion of the data base for an actual project, the two systems are compared for some typical reports. Figure 7 shows a summary of the programmed net area for each work station, produced by RAMIS.

Table 3 presents the comparisons.



```
CONFERENCE ROOM STUDY                                             SKIDMORE, OWINGS AND MERRILL
BAXTER LABORATORIES

CODE     QUAN WS  FREQ  PERIOD  ANNUALLY  PC 6  HRS(6 MAN)  PC 14  HRS(14 MAN)  COM DUR  PC AIDS  CONF AID  LRG GRP
----     -------  ----  ------  --------  ----  ----------  -----  -----------  -------  -------  --------  -------
BIVC1       1       1   MONTH         12   90         21.6   10            2.4     2.00    0        00            10
BIVDC1      1       1   MONTH         12   99         23.8    1             .2     2.00   20                       6
BIVDE1      1       3   WEEK         156   70        109.2   30           46.8     1.00   99        CB            14
BIVDI1      1       1   WEEK          52   90         23.4   10            2.6      .50   25        PR             8
BIVDT1      1       1   WEEK          52   50         39.0   50           39.0     1.50    0        00             8
BIVD1       1       1   WEEK          52   80         83.2   20           20.8     2.00   30        PR            10
BIVI1       1       2   MONTH         24   90         43.2   10            4.8     2.00   25        EA             6
BIV1        1       4   YEAR           4   50          3.0   50            3.0     1.50   50        CS            10

TOTAL       8                        364              346.4                119.6    12.50                          72
```

Figure 6. Typical RAMIS Output: Tabulation of Annual Conference Room Requirements

	RAMIS	TABLE
A. File Definition		
1. Initial Definition		
Prompting	Yes	No
Data Types		
Alphanumeric, Integer, Single or Double Precision	Yes	Yes
Decimal	No	No
Maximum Length of Variable Alphanumeric Field	72	123
Maximum Length of Field Name	12	8
Short Form of Field Name	Yes	No
Units	No	Yes
2. Update File Definition		
Add or Delete Fields	No	Yes
B. File Maintenance		
1. Input		
Check for Data Type	Yes	Yes
Check for Length of Character String Data	Yes	Yes
Check for Numeric Value	Yes	No
Special User Input Routine Interface	Yes	Yes (1)
Fixed Format	Yes	No
Free Format	Yes	Yes
Omit Input for Duplicate Values	Yes	No
External Input Files	Yes	No
Conversion to Correct Units	No	Yes
Scaling of Input Values	Yes	No
Insert Values in All Input Records	Yes	No
2. Update		
Change Values in Place	Yes	Yes
Delete Records	Yes	Yes
Cumulative, Selective and Global Updates	Yes	No
Data Checks as for Input	Yes	Yes
Edit Data Base On-Line (for all Input and Updating)	Yes	No
3. Transfer Part or All of One File to Another File	No (2)	Yes
C. Reports		
1. Sorted Reports	Yes	Yes
Maximum Number of Sort Fields	15	1
Maximum Number of Lines per Report	3000+	Unlimited
2. Selective Reporting	Yes	Yes
Summary at Various Levels	Yes	No
Mathematical Operations on Columns of Report	Yes	No
3. Temporary Fields (defined for a report)		
Conditionals	Yes	NA (3)
Arithmetic Operations and String Operations	Yes	NA (3)
Conversion (Alphabetic to Integer and vice-versa)	Yes	NA (3)
4. Built-In Functions		
Column Total	Yes	Yes (4)
Row Total, Sub Total, Maximum, Minimum, Square Root	Yes	No
Average, Percent, Average of Squares, First, Last	Yes	No
5. Graphs and Bar Charts	Yes	No
6. Catalogued Requests	Yes	No

Notes

1. User input routine responsible for interface with TABLE file access routines.
2. HOLD and ALTER commands permit transfer to a permanent one-level sequential file.
3. Some of these operations possible upon one heading or ordering at a time.
4. For one ordering at a time.

Table 2. Operational and Functional Capabilities

```
CODE.          NAME                              INTRVWD  CAT1  MEN  WOMEN  QUAN HS   AREA
--------       ----                              -------  ----  ---  -----  -------   ----
RIV     1      VICE PRESIDENT INTERNATIONAL      ORF      02    1    0      1         252.00
RIV     2      SECY VP  INTERNATIONAL            CW       07    0    1      1          95.90
RIVC    1      CONSTRUCTION ENGINEERING MGR      MF       04    1    0      1         156.00
RIVC    2      SECY CONST ENGINEERING MGR        MF       07    0    1      1          56.25
RIVC    3      FILING.LEGAL SIZE                 MF       00    0    0      1          41.25
RIVC    4      BLUE PRINT FILES                  MF       00    0    0      1          26.00
RIVC    5      BLUE PRINT CABINET                MF       00    0    0      3          36.00
RIVC    6      BOOKCASE                          MF       00    0    0      1          48.00
RIVCE   1      PROJECT ENGINEER                  MF       05    1    0      2         200.00
RIVCE   2      ASSISTANT PROJECT ENGINEER        MF       06    1    0      2         200.00
RIVCE   3      SECY PROJECT ENGINEERS            MF       07    0    1      1          56.25
RIVCE   4      WORK TABLE FOR VIEWING PLANS      MF       00    0    0      1          45.00
RIVD    1      DISTRIBUTION MGR                  JDO      04    1    0      1         156.00
RIVD    2      SECY DISTRIBUTION MANAGER         SM       07    0    1      1          56.25
RIVD    3      FILING                            GD       00    0    0      1          33.00
RIVD    4      XEROX AND STORAGE                 BIV      00    0    0      0            .00
RIVDC   1      CUSTOMER SERVICE MANAGER          LNR      06    1    0      1          97.50
RIVDC   2      SECY ORDER ENTRY                  LNR      07    0    1      1          56.25
RIVDC   3      ORDER ENTRY CLERKS                LNB      07    0    1      4         225.00
RIVDC   4      FILING LETTER SIZE                LNR      00    0    0      1          20.63
RIVDC   5      STORAGE PRINT OUT BOOKS           LNB      00    0    0      1          22.50
RIVDC   6      STORAGE REGISTER BKS & FORMS      LNR      00    0    0      1          25.00
RIVDE   1      EXPORT SERVICES MANAGER           RR       06    1    0      1          80.75
RIVDE   2      CENTRAL FILING.SHELF FILING       RR       00    0    0      1         135.00
RIVDE   3      CENTRAL FILING.LETTER SIZE        RB       00    0    0      1          20.63
RIVDE   4      CENTRAL FILING BOOKCASE           BB       00    0    0      1          20.00
RIVDE   5      PORTABLE CALCULATOR STANDS        RB       00    0    0      3          18.00
RIVDEC  1      EXPORT COORDINATOR                RR       07    0    1      2         142.50
RIVDEC  2      DOCUMENTATION SECY                RB       07    0    1     13         731.25
RIVDES  2      IBM 26 CARD PUNCH                 RR       00    0    0      1          25.00
RIVDES  3      VICTOR 800 SERIES BILLING MACH    RR       00    0    0      1          30.00
RIVDES  4      TAB CARD FILE                     RR00     00    0    0      1          25.00
RIVDES  5      SHELF FILING                      RR       00    0    0      1          12.00
```

Figure 7. Typical RAMIS Output: Work Station Area Summary

	RAMIS	RAMIS	TABLE
A. <u>Storage Requirements</u>			
Number of Items	57	57	57
Number of Files	2	1	1
Number of Fields	108	54	80
Number of Characters (approximate)	31,900	35,700	40,700
B. <u>Output of Reports</u>			
1. Print Reports for Entire Basic File			
Number of Reports		9	9
Number of Lines Printed		1039	1727
Number of Disk Accesses		625	1410
CPU Time (seconds)		25.04	26.24
Relative Cost (not in dollars)		6.17	6.53
2. Print Summary Report with Area			
Number of Reports		1	1
Number of Lines Printed		114	254
Number of Disk Accesses		330	127
CPU Time (seconds)		5.93	5.94
Relative Cost (not in dollars)		1.55	1.00

<u>Notes</u>

1. Execution times for RAMIS are for an IBM 360/67, for TABLE for a 360/65.
2. Costs are for remote batch execution, exclusive of storage charges, connect charges and royalties.

Table 3. Comparison of RAMIS and TABLE for Storage and Output of a 57-Item File

Preparation and checking of input for the two systems should be comparable, as should the definition of commands required to generate typical reports. The more powerful capabilities of RAMIS permit the generation of some reports that in TABLE would be difficult or even impossible without additional program development.

As mentioned above, RAMIS files have the potential for reducing storage and search time because a tree structure is used for storing information. The savings produced are wholly dependent on the nature and structure of the information stored. In the data chosen for the example, a direct translation of the data structure and entries from the TABLE files to RAMIS produced a 20 per cent reduction in storage requirements. Attempts to reduce the amount of storage further through a conceptual hierarchy were futile, primarily because the TABLE information structure was a simple two-level structure. The first level was a code for a work station which included information about its position in the administrative hierarchy; the second was detailed information about that work station.

Some data, such as the names of administrative departments, had been excluded from the TABLE file, because this space-consuming information would have had to be repeated for each work station. Therefore, some of the potential savings in RAMIS were not possible.

More efficient storage in RAMIS is possible if the number of records formed at one branching level is relatively consistent from one record to the next. A wide discrepancy results in the allocation of more space than required or in an excess of pointers being created. In this case there was a large variation in the number of records required from one work station to another, and thus RAMIS overhead tended to be higher than normal.

Conclusions

Architects can successfully apply available generalized information management systems to the storage and retrieval of architectural and interiors program data. Two systems, RAMIS and TABLE, have been described and compared. From the comparison the major criteria for selecting or evaluating similar systems may be summarized.

The information management system should have sufficient capacity for the volume of data to be stored. Since the data base is usually segmented for economy and ease of processing, capacities of RAMIS and TABLE appear to be adequate for storing architectural programs. The system should also provide the user with a command language and a wide range of selective inquiry and reporting operations.

Additional computer programming by the user should not be necessary except in special circumstances. For these, however, some interfaces with user-written routines should be provided. An architect wants to minimize the amount of software development and to concentrate on analyzing the client's requirements. In this respect RAMIS has significant advantages.

Continuing maintenance and support for the system should be available.

The information management system should be available in both batch and time-sharing versions on a computer system that permits both modes of operation, so that the architect can combine the convenience of terminal input and quick interactive response with the economies of off-line processing and storage. The mix can then vary, but under user control.

As in the case of most computer applications, the advantages of a computer-maintained data base for architectural program information are largely in systematizing the programming process, reducing errors and improving response time. The most exciting prospect of these systems is the possibility of rapid extraction and analysis of the data to answer unforeseen questions in time to contribute to important design decisions.

Thus far, information management systems such as RAMIS and TABLE have been considered as self-contained systems, including their own capabilities for arithmetic manipulation and report generation. To produce drawings, perform space allocation or circulation studies, structural or mechanical system studies, and many other building design tasks, the data base must be linked to special-purpose architectural and engineering programs. In this way the data base becomes part of a computer-aided design system.

The integration of data base with analysis and design algorithms at the scale of building design problems has been a goal ever since the potential of computer-assisted architecture became apparent. How to achieve this integration remains a major subect of investigation. One recent study used TABLE as the mechanism for maintaining building design data common to several subsystems of design programs. (14) Other similar attempts can be expected in the future. In the meantime an independent information management system can be a valuable aid to the practicing architect in maintaining and analyzing program data for project use.

Acknowledgments

The assistance of members of the Skidmore, Owings and Merrill computer group in Chicago, New York and San Francisco in preparing these comparative examples is gratefully acknowledged.

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TRANSLATING INDIVIDUAL CONSTRUCTION PROJECT INFORMATION INTO THE RESOURCES REQUIRED FOR CONSTRUCTION

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The volume of construction which can be built in a region is limited by the resources which the region can marshall to accomplish the work. Thinking of this in supply and demand terms, each construction project represents a unit of demand; a particular mix of construction labor, materials, contractors and financing must be supplied if the project is to be built. Where the capacity of a regional market to place construction is stressed, the results are felt in unreasonably high bids, time slippages and a general "all bets are off" attitude.

Currently all segments of the construction industry operate almost "in the dark" regarding future conditions of the market. Owners and architects make decisions about their projects many months before they are bid with little knowledge of future merket conditions. Yet these early decisions (decisions on project "packaging" for bidding, bidding dates, major construction system materials, etc.) have a significant effect on whether or not the project will be "marketable" -- whether or not it can be economically built (along with the other projects) with the set of construction resources that will be available at that time and place. Contractors, business agents and material suppliers act to determine the level of resources which can possibly be made available with little knowledge of the future demand for their services.

BIDS: a Response

In an effort to provide needed information about construction markets, the Center for Architectural Research has been developing a computer-based construction information and analysis system, BIDS (for Building Industry Data System). When fully operational, this system will:

1. Collect historical, current and projected information about the supply of construction resources (manpower, materials, management and money) on a regional basis.
2. Collect information about the historical, current and projected demand for these resources; that is, collect information about construction projects.
3. Relate these two types of information to produce some sort of market "picture" for each region.
4. Distribute this information to each user segment so it could be used in decision making.
5. Do this on a continuing, perhaps monthly, basis.

A series of studies* has moved this effort from the feasibility stage to an operational system which is now undergoing evaluation in a case study area of New York State.

The Case Study

After preliminary development of the system, a five county case study region in the southern tier of New York State (the Binghamton Region) was chosen as the first area for implementation. Work was started to identify potential users of BIDS and to start the flow of information it would need to work on. In parallel, the system design was refined, initial capabilities determined and the initial set of computer programs written.

This initial version of BIDS became operational in February of 1971, accepting information on past, present and anticipated construction projects in the Binghamton Region. Each month information on new projects, and updates for projects already on file are received from owners and architects. This information is coded, keypunched and readied for data processing. The monthly computer run provides the 800 plus active BIDS users with two levels of information about future market conditions:

1. A listing of active construction PROJECTS; a sort of medium range bidding calendar.

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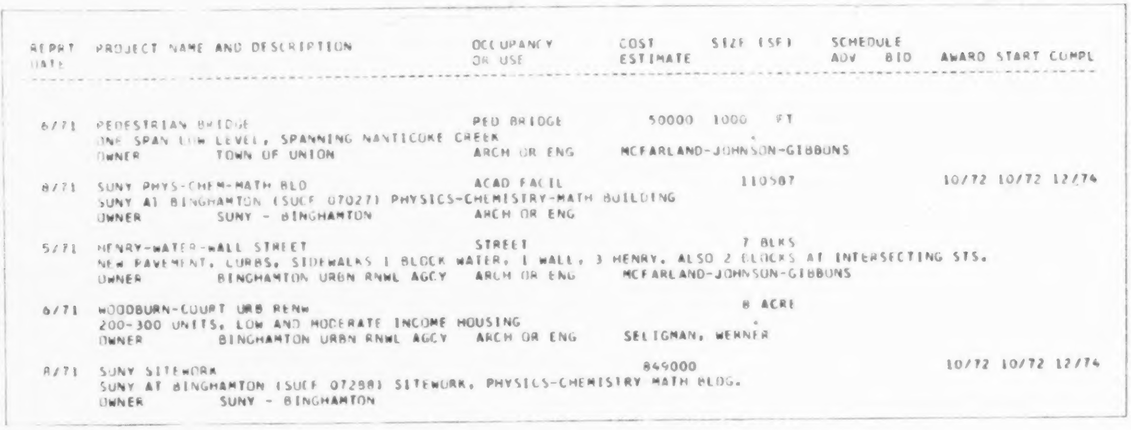
* From its inception in 1967, the development of BIDS has been sponsored by one of the largest program builders in New York State, the State University Construction Fund and supported by several other agencies including the Office of Planning Services, the Council on Architecture, and the Office of General Services.

THE INITIAL VERSION OF BIDS PROVIDES TWO PRODUCTS....



```
REPRT  PROJECT NAME AND DESCRIPTION                  OCCUPANCY          COST        SIZE (SF)     SCHEDULE
DATE                                                 OR USE             ESTIMATE                  ADV    BID    AWARD START COMPL
-------------------------------------------------------------------------------------------------------------------------------


 6/71  PEDESTRIAN BRIDGE                             PED BRIDGE            50000  1000    FT
       ONE SPAN LOW LEVEL, SPANNING NANTICOKE CREEK
       OWNER        TOWN OF UNION                    ARCH OR ENG        MCFARLAND-JOHNSON-GIBBONS

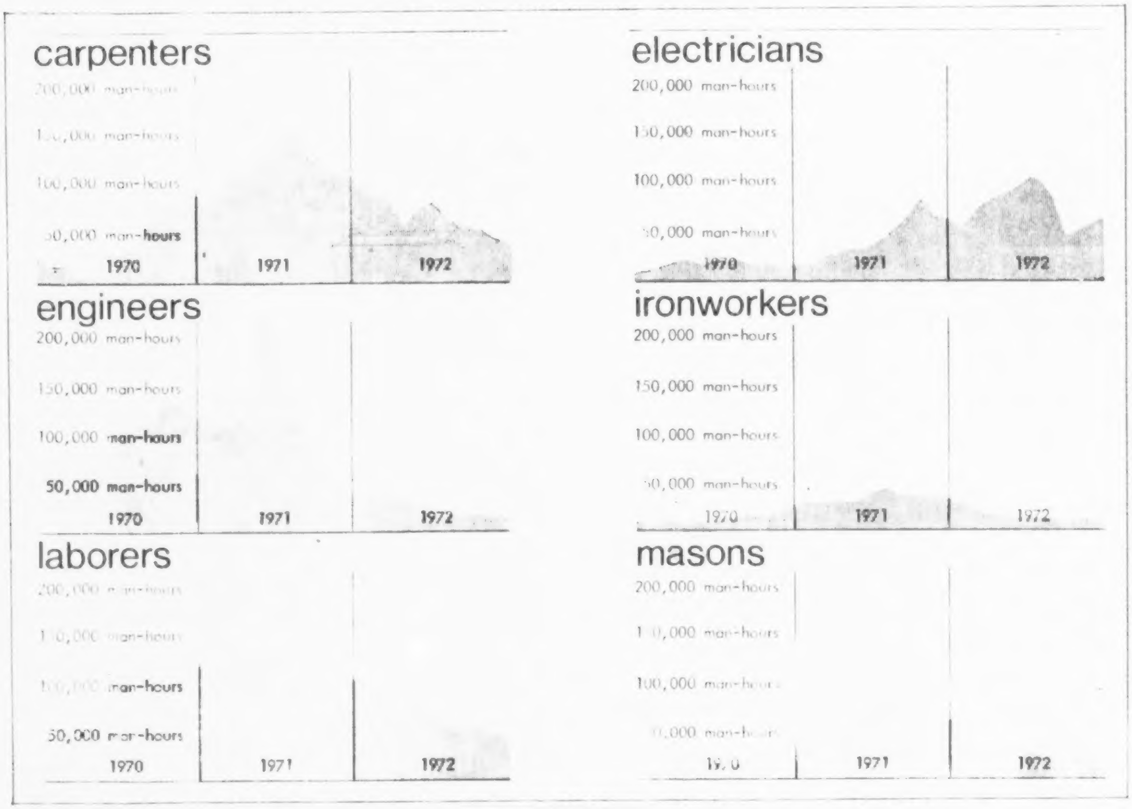
 8/71  SUNY PHYS-CHEM-MATH BLD                       ACAD FACIL                   110587                       10/72 10/72 12/74
       SUNY AT BINGHAMTON (SUCF 07027) PHYSICS-CHEMISTRY-MATH BUILDING
       OWNER        SUNY - BINGHAMTON                ARCH OR ENG

 5/71  HENRY-WATER-WALL STREET                       STREET                       7 BLKS
       NEW PAVEMENT, CURBS, SIDEWALKS 1 BLOCK WATER, 1 WALL, 3 HENRY. ALSO 2 BLOCKS AT INTERSECTING STS.
       OWNER        BINGHAMTON URBN RNWL AGCY        ARCH OR ENG        MCFARLAND-JOHNSON-GIBBONS

 6/71  WOODBURN-COURT URB RENW                                                    8 ACRE
       200-300 UNITS, LOW AND MODERATE INCOME HOUSING
       OWNER        BINGHAMTON URBN RNWL AGCY        ARCH OR ENG        SELIGMAN, WERNER

 8/71  SUNY SITEWORK                                                   849000                                  10/72 10/72 12/74
       SUNY AT BINGHAMTON (SUCF 07288) SITEWORK, PHYSICS-CHEMISTRY MATH BLDG.
       OWNER        SUNY - BINGHAMTON
```

1. A PROJECT LISTING



2. A LABOR FORECAST

FIGURE 1: SOME SAMPLE BIDS "PRODUCTS"

2. An estimate of the past, present and future DEMAND for construction labor in the region.

Figure 1 presents samples of these two BIDS "products".

This Paper

The second BIDS product, the "labor forecast" is a significant addition to the information provided by current construction information services and provides BIDS users with some hard information about the future condition of at least the labor component of the market. This paper focuses on the mechanism which produces these labor estimates, the "job profiler".

The Profiling Concept

Conceptually, the profiling mechanism is a translator. It starts with information about a project (a unit of demand) and translates this information into the pattern of resources (units of supply) required to build the project. Such a pattern or "profile" indicates not only the total quantity of each resource that will be needed, but its consumption pattern over the duration of the project (see Figure 2).

When placed in a time frame, the resources required by all projects can be aggregated to estimate the overall pattern of demand in a region.

General Approach

The initial version of the job profiler is limited to profiling projects in terms of their labor requirements. Dealing with the projects one at a time, the profiler:

- inspects the projects to determine the appropriate procedure for profiling,
- retrieves information from its files which will be needed,
- calculates the labor profile for the project, and
- adds the estimated demand for this project to the county and regional totals.

What follows is a more detailed look at the "guts" of this mechanism, including:

PROJECT INFORMATION. What is the minimum information which must be known about a project? What additional information is desirable?

FILES. What files are needed? What is in each? How are these structured?

PROCEDURES. What are the various paths through the profiler? How are the calculations performed?

REPORTS. What levels of reports are possible?

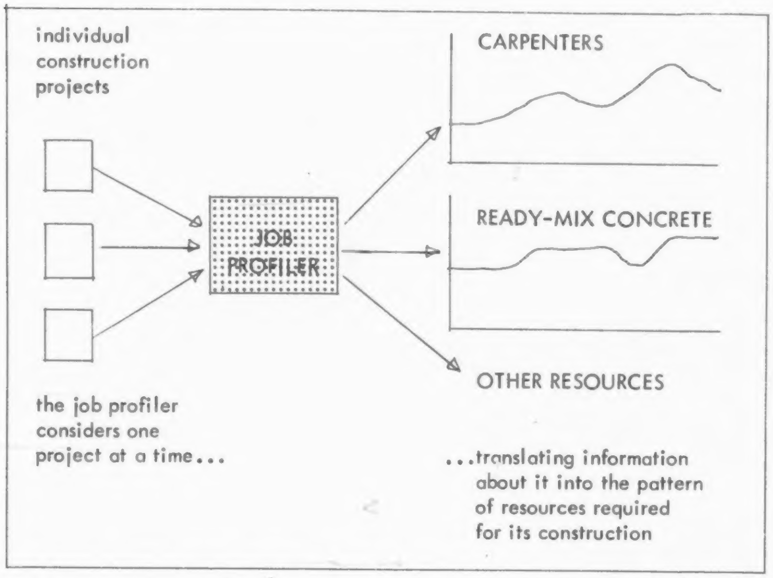
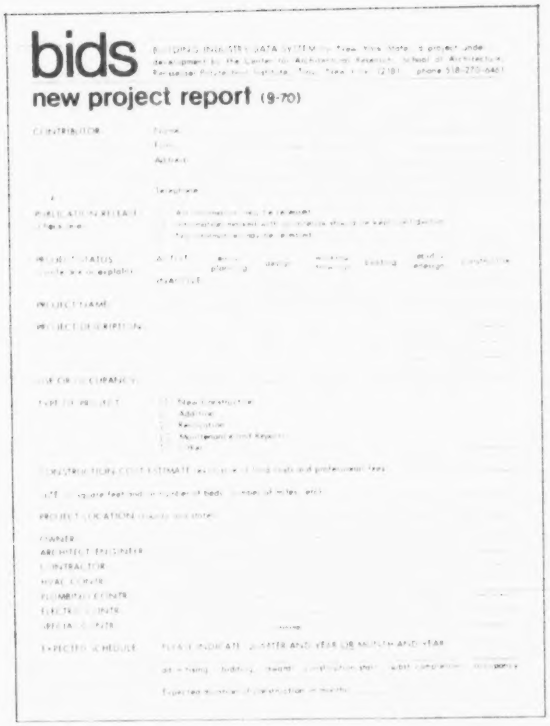

individual construction projects
JOB PROFILER
CARPENTERS
READY-MIX CONCRETE
OTHER RESOURCES
the job profiler considers one project at a time...
...translating information about it into the pattern of resources required for its construction

FIGURE 2: THE PROFILING CONCEPT



bids

BUILDING INDUSTRY DATA SYSTEM for New York State, a project under development by the Center for Architectural Research, School of Architecture, Rensselaer Polytechnic Institute, Troy, New York 12181 phone 518-270-6461

new project report (9-70)

CONTRIBUTOR: Name / Firm / Address / Telephone

PUBLICATION RELEASE

PROJECT STATUS

PROJECT NAME

PROJECT DESCRIPTION

USE OR OCCUPANCY

TYPE OF PROJECT: New Construction / Addition / Renovation / Maintenance and Repairs / Other

CONSTRUCTION COST ESTIMATE

PROJECT LOCATION

OWNER

ARCHITECT ENGINEER

CONTRACTOR

HVAC CONTR.

PLUMBING CONTR.

ELECTRIC CONTR.

SPECIAL CONTR.

EXPECTED SCHEDULE: PLEASE INDICATE QUARTER AND YEAR OR MONTH AND YEAR

Expected duration of construction in months

FIGURE 3: BIDS NEW PROJECT REPORT

Project Information
Figure 3 is a sample of the form a BIDS contributor uses to submit a project for the first time. As can be seen, BIDS collects the usual identifying and descriptive information about each construction project; this is used in the project listing. But it must have five key peices of information about a project to be able to profile it:

- COUNTY in which the project is located
- USE OR OCCUPANCY of the project (church, road, golf course, etc)
- SCOPE OF WORK involved (new construction, roofing repairs, addition of an air conditioning system, resurfacing, etc.)
- CONSTRUCTION BUDGET which is considered to be the expected contractor's bid (does not include land costs, professional fees, furniture, etc.)
- KEY SCHEDULING DATES, the expected start of construction and substantial completion dates (either in month and year or quarter and year)

Once this information is in the file, a similar computer produced form containing all the information a user contributed is produced and returned for review each month. In this way, the information on each project is kept up-to-date.

If the project is a new building, it is desirable to know more about the project -- labor requirements for a project are significantly affected by material and building system decisions. In this case, the update form also requests information about the project's "work categories" (see Figure 4).

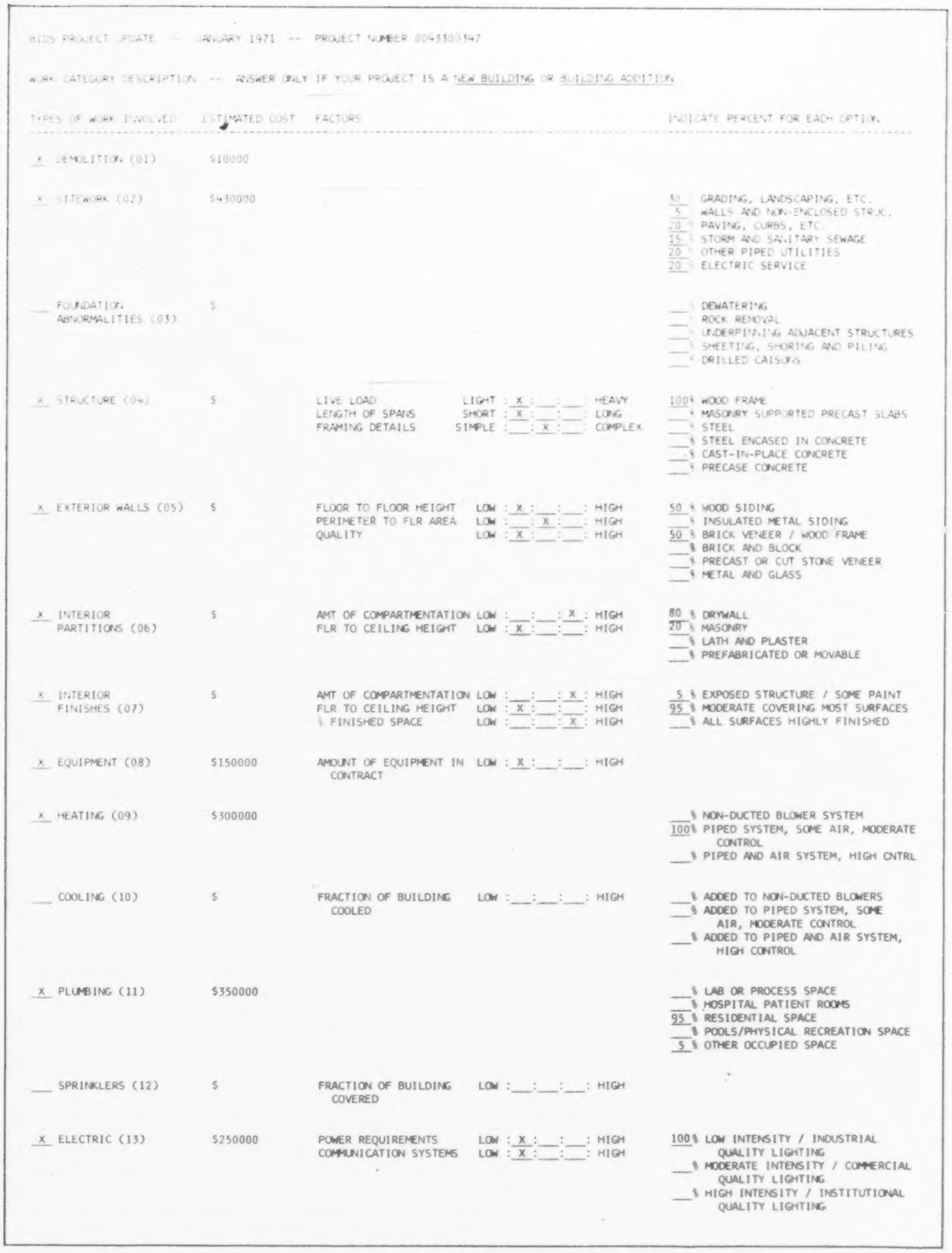
Three types of information may be requested for each work category:

- ESTIMATED COST, the anticipated cost of the particular type of work
- FACTORS, simple three part scales which characterize the type of work
- OPTIONS, usually material oriented

In summary, to be profiled BIDS must know a minimum level of information about a construction project. In the case of new buildings, as material and building system decisions are made, this information is collected and kept current through the monthly update form.

Files
The BIDS system sets up and uses several data files, including one which contains user records and one, of course, which contains information on each project. Four files are of particular interest to the job profiling part of the system. Each is identified below; how they are used in profiling follows.

1. HISTORICAL FILE, structured by county and occupancy key. Each record contains "typical" materials and building systems information which reflects the historical or expected way this type of building is constructed in the county.
2. WORK CATEGORY FILE, structured by work category and option (i.e. structure/wood). Records contain:
   a. weights for the factors information for that category,
   b. a base cost per square foot for the work category and option,
   c. percentage which allows the dollars assigned to this work category to be split into labor dollars and "other" dollars,
   d. a set of percentages for distributing the labor dollars among trades and
   e. another set of percentages for distributing the dollars for each trade over deciles of the job's duration.



```
BIDS PROJECT UPDATE  --  JANUARY 1971  --  PROJECT NUMBER 0043300347

WORK CATEGORY DESCRIPTION  --  ANSWER ONLY IF YOUR PROJECT IS A NEW BUILDING OR BUILDING ADDITION

TYPES OF WORK INVOLVED   ESTIMATED COST   FACTORS                                            INDICATE PERCENT FOR EACH OPTION
-----------------------------------------------------------------------------------------------------------------------------

_X_ DEMOLITION (01)      $10000

_X_ SITEWORK (02)        $430000                                                             30_% GRADING, LANDSCAPING, ETC.
                                                                                             _5_% WALLS AND NON-ENCLOSED STRUC.
                                                                                             20_% PAVING, CURBS, ETC.
                                                                                             15_% STORM AND SANITARY SEWAGE
                                                                                             20_% OTHER PIPED UTILITIES
                                                                                             20_% ELECTRIC SERVICE

___ FOUNDATION           $                                                                   ___% DEWATERING
    ABNORMALITIES (03)                                                                       ___% ROCK REMOVAL
                                                                                             ___% UNDERPINNING ADJACENT STRUCTURES
                                                                                             ___% SHEETING, SHORING AND PILING
                                                                                             ___% DRILLED CAISONS

_X_ STRUCTURE (04)       $                LIVE LOAD               LIGHT :_X_:___:___: HEAVY    100% WOOD FRAME
                                          LENGTH OF SPANS         SHORT :_X_:___:___: LONG     ___% MASONRY SUPPORTED PRECAST SLABS
                                          FRAMING DETAILS        SIMPLE :___:_X_:___: COMPLEX  ___% STEEL
                                                                                             ___% STEEL ENCASED IN CONCRETE
                                                                                             ___% CAST-IN-PLACE CONCRETE
                                                                                             ___% PRECASE CONCRETE

_X_ EXTERIOR WALLS (05)  $                FLOOR TO FLOOR HEIGHT     LOW :_X_:___:___: HIGH     50_% WOOD SIDING
                                          PERIMETER TO FLR AREA     LOW :___:_X_:___: HIGH     ___% INSULATED METAL SIDING
                                          QUALITY                   LOW :_X_:___:___: HIGH     50_% BRICK VENEER / WOOD FRAME
                                                                                             ___% BRICK AND BLOCK
                                                                                             ___% PRECAST OR CUT STONE VENEER
                                                                                             ___% METAL AND GLASS

_X_ INTERIOR             $                AMT OF COMPARTMENTATION LOW :___:___:_X_: HIGH     80_% DRYWALL
    PARTITIONS (06)                       FLR TO CEILING HEIGHT     LOW :_X_:___:___: HIGH     20_% MASONRY
                                                                                             ___% LATH AND PLASTER
                                                                                             ___% PREFABRICATED OR MOVABLE

_X_ INTERIOR             $                AMT OF COMPARTMENTATION LOW :___:___:_X_: HIGH     _5_% EXPOSED STRUCTURE / SOME PAINT
    FINISHES (07)                         FLR TO CEILING HEIGHT     LOW :_X_:___:___: HIGH     95_% MODERATE COVERING MOST SURFACES
                                          % FINISHED SPACE          LOW :___:___:_X_: HIGH     ___% ALL SURFACES HIGHLY FINISHED

_X_ EQUIPMENT (08)       $150000          AMOUNT OF EQUIPMENT IN    LOW :_X_:___:___: HIGH
                                            CONTRACT

_X_ HEATING (09)         $300000                                                             ___% NON-DUCTED BLOWER SYSTEM
                                                                                             100% PIPED SYSTEM, SOME AIR, MODERATE
                                                                                                    CONTROL
                                                                                             ___% PIPED AND AIR SYSTEM, HIGH CNTRL

___ COOLING (10)         $                FRACTION OF BUILDING      LOW :___:___:___: HIGH     ___% ADDED TO NON-DUCTED BLOWERS
                                            COOLED                                           ___% ADDED TO PIPED SYSTEM, SOME
                                                                                                    AIR, MODERATE CONTROL
                                                                                             ___% ADDED TO PIPED AND AIR SYSTEM,
                                                                                                    HIGH CONTROL

_X_ PLUMBING (11)        $350000                                                             ___% LAB OR PROCESS SPACE
                                                                                             ___% HOSPITAL PATIENT ROOMS
                                                                                             95_% RESIDENTIAL SPACE
                                                                                             ___% POOLS/PHYSICAL RECREATION SPACE
                                                                                             _5_% OTHER OCCUPIED SPACE

___ SPRINKLERS (12)      $                FRACTION OF BUILDING      LOW :___:___:___: HIGH
                                            COVERED

_X_ ELECTRIC (13)        $250000          POWER REQUIREMENTS        LOW :_X_:___:___: HIGH     100% LOW INTENSITY / INDUSTRIAL
                                          COMMUNICATION SYSTEMS     LOW :_X_:___:___: HIGH            QUALITY LIGHTING
                                                                                             ___% MODERATE INTENSITY / COMMERCIAL
                                                                                                    QUALITY LIGHTING
                                                                                             ___% HIGH INTENSITY / INSTITUTIONAL
                                                                                                    QUALITY LIGHTING
```

FIGURE 4: BIDS PROJECT UPDATE WORK CATEGORY DESCRIPTION

3. HEAVY USE AND SPECIAL SCOPE FILE, structured by heavy use key (roads, etc.) and special scope key (rennovation, etc.). Each record contains:

   a. a labor percentage which allows a labor dollars, other dollars split,
   b. a set of percentages for distributing the labor dollars among trades, and
   c. a set of percentages for each trade for distributing that trade's dollars over the deciles of the job's duration.

4. WAGE RATE FILE, structured by county and trade. Records contain a set of wage rates for each trade and the dates on which each rate became (or is expected to become) effective.

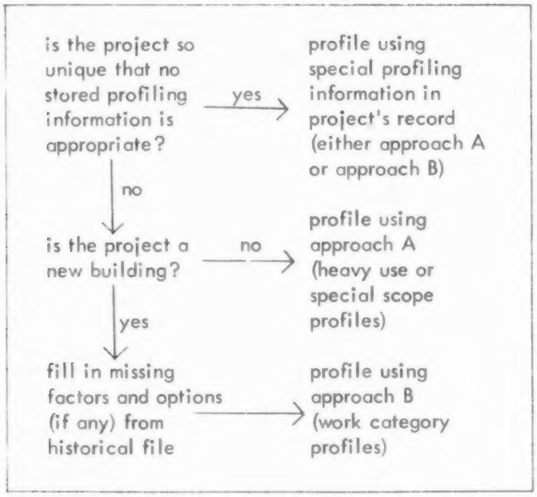

is the project so unique that no stored profiling information is appropriate?
yes
profile using special profiling information in project's record (either approach A or approach B)
no
is the project a new building?
no
profile using approach A (heavy use or special scope profiles)
yes
fill in missing factors and options (if any) from historical file
profile using approach B (work category profiles)

FIGURE 5:
SELECTING THE PROFILING APPROACH

Profiling Procedures

There are two basic approaches the job profiler uses in estimating the labor requirements of a project:

APPROACH A, the least complicated simply applies a stored set of percentages to distribute the budget of the project among trades and over time.

APPROACH B works on a work category by work category basis, finally summing up the labor requirements of all the work categories to produce the project estimate.

Figure 5 presents the logic used in determining which approach will be taken on a particular project.

Significantly, the first question is whether or not the project can be handled with reasonable accuracy by any of the system stored profiling data -- obviously a professional judgment. Where a unique project is found, special profiling data is developed for that project and entered into the project's file. Either APPROACH A or APPROACH B will be followed depending on the form of this special profiling data.

If the project is not unique, the profiler looks to see if it is dealing with a new building project. If not -- if the project is a road, bridge, addition of an air conditioning system, installation of traffic signals, or the like -- the project is profiled using APPROACH A.

If the project is a new building, the profiler inspects the information in the work category section of the project's record. If the factors and options have all been entered, the project is ready for profiling. If not, historical answers to these questions are retrieved from the HISTORICAL FILE. In any case, new building projects are profiled using APPROACH B.

PROFILING APPROACH "A" requires four steps to estimate the labor requirements of a project:

1. Retrieve the appropriate heavy use or special scope profiling data (or a similar set of data from the project's record if special profiling data has been provided). Figure 6 presents the SPECIAL SCOPE profiling data for "General Building Rehabilitation" as an example of the type of information contained in these files.

2. Apply the labor percentage to find the labor dollars for the project.

3. Distribute the labor dollars among the trades using the trade percentage distribution.

4. Distribute the trade dollars over the deciles of the job's duration using the decile distribution for each trade.

SPECIAL SCOPE PROFILING DATA FOR
"General Building Rehabilitation"

percent labor

62%

trade distribution

Carpenters	11%
Electricians	13%
Operating Engineers	--
Ironworkers	2%
Laborers	21%
Masons	10%
Plumbers	11%
Steamfitters	11%
Sheetmetal Workers	3%
Others	18%

decile distribution for carpenters

1st decile	--
2nd	--
3rd	5%
4th	5%
5th	10%
6th	15%
7th	15%
8th	15%
9th	20%
10th	15%

similar decile distributions for other trades

FIGURE 6:
APPROACH "A" PROFILING DATA

WORK CATEGORY PROFILING DATA FOR
"Work Category 4, Structure, Steel Option"

factors

	low	med	high
live load	.95	1.00	1.15
length of spans	.95	1.00	1.15
framing details	.95	1.00	1.15

stored cost per gross square foot of building area

$6.50

percent labor

43%

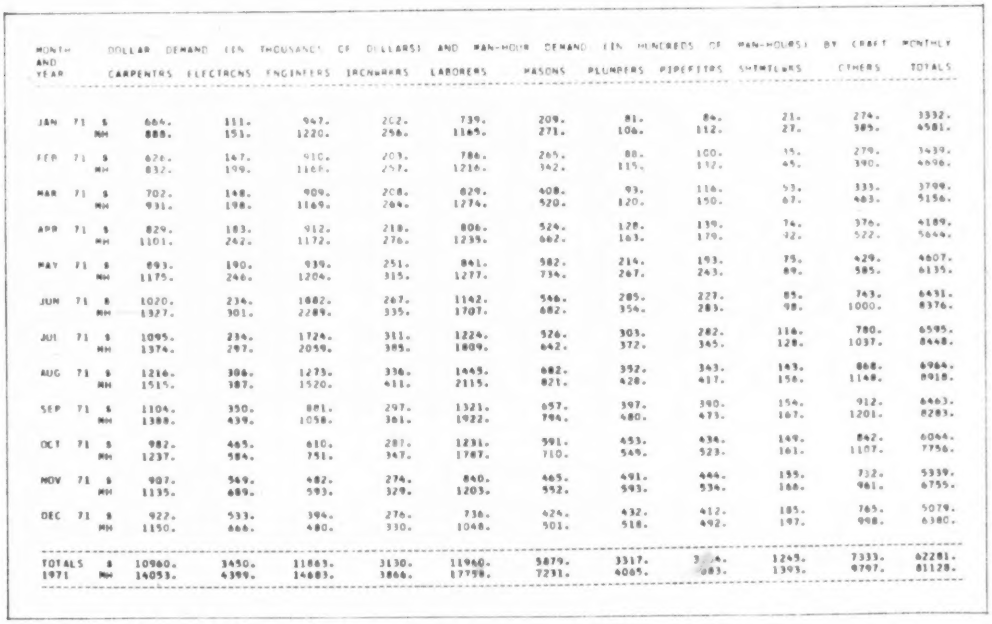
trade distribution

Carpenters	26%
Electricians	--
Operating Engineers	16%
Ironworkers	30%
Laborers	12%
Masons	7%
Plumbers	--
Steamfitters	--
Sheetmetal Workers	--
Others	9%

decile distribution for all trades

1st decile	10%
2nd	25%
3rd	19%
4th	13%
5th	15%
6th	18%
7th	--
8th	--
9th	--
10th	--

FIGURE 7:
APPROACH "B" PROFILING DATA



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MONTH       DOLLAR  DEMAND  (IN  THOUSANDS  OF  DOLLARS)  AND  MAN-HOUR  DEMAND  (IN  HUNDREDS  OF  MAN-HOURS)  BY  CRAFT  MONTHLY
AND
YEAR        CARPENTRS  ELECTRCNS  ENGINEERS  IRONWRKRS  LABORERS    MASONS  PLUMBERS  PIPEFITRS  SHTMTLWRS    OTHERS   TOTALS
-------------------------------------------------------------------------------------------------------------------------------

JAN  71  $     664.       111.       947.       202.       739.      209.       81.       84.        21.      274.    3332.
        MH     888.       151.      1220.       256.      1165.      271.      106.      112.        27.      385.    4581.

FEB  71  $     626.       147.       910.       203.       786.      265.       88.      100.        35.      279.    3439.
        MH     832.       199.      1166.       257.      1216.      342.      115.      132.        45.      390.    4696.

MAR  71  $     702.       148.       909.       208.       829.      408.       93.      116.        53.      333.    3799.
        MH     931.       198.      1169.       264.      1274.      520.      120.      150.        67.      483.    5156.

APR  71  $     829.       183.       912.       218.       806.      524.      128.      139.        74.      376.    4189.
        MH    1101.       242.      1172.       276.      1235.      662.      163.      179.        92.      522.    5644.

MAY  71  $     893.       190.       939.       251.       841.      582.      214.      193.        75.      429.    4607.
        MH    1175.       246.      1204.       315.      1277.      734.      267.      243.        89.      585.    6135.

JUN  71  $    1020.       236.      1082.       267.      1142.      546.      285.      227.        85.      743.    6431.
        MH    1327.       301.      2289.       335.      1707.      682.      354.      283.        98.     1000.    8376.

JUL  71  $    1095.       234.      1724.       311.      1224.      526.      303.      282.       116.      780.    6595.
        MH    1374.       297.      2059.       385.      1809.      642.      372.      345.       128.     1037.    8448.

AUG  71  $    1216.       306.      1273.       336.      1445.      682.      352.      343.       143.      868.    6964.
        MH    1515.       387.      1520.       411.      2115.      821.      428.      417.       156.     1148.    8918.

SEP  71  $    1104.       350.       881.       297.      1321.      657.      397.      390.       154.      912.    6463.
        MH    1388.       439.      1058.       361.      1922.      794.      480.      473.       167.     1201.    8283.

OCT  71  $     982.       465.       610.       287.      1231.      591.      453.      434.       149.      842.    6044.
        MH    1237.       584.       751.       347.      1787.      710.      549.      523.       161.     1107.    7756.

NOV  71  $     907.       549.       482.       274.       840.      465.      491.      444.       155.      732.    5339.
        MH    1135.       689.       593.       329.      1203.      552.      593.      534.       168.      961.    6755.

DEC  71  $     922.       533.       394.       276.       736.      424.      432.      412.       185.      765.    5079.
        MH    1150.       666.       480.       330.      1048.      501.      518.      492.       197.      998.    6380.

-------------------------------------------------------------------------------------------------------------------------------
TOTALS   $   10960.      3450.     11863.      3130.     11960.     5879.     3317.  3[illegible]4.  1245.     7333.   62281.
1971    MH   14053.      4399.     14683.      3866.     17758.     7231.     4065.  [illegible]83.  1393.     9797.   81128.
-------------------------------------------------------------------------------------------------------------------------------
```

FIGURE 8: SAMPLE REGIONAL REPORT PRODUCED BY THE JOB PROFILER

PROFILING APPROACH "B" is more complex:

1. Subtract any known work category dollars from the project's construction budget (looking back at Figure 4, budget estimates for some work categories may be provided).

2. Retrieve appropriate work category profiling data. Figure 7 presents the work category profiling data for work category 4 (STRUCTURE), option 3 (STEEL) as an example.

3. For each of the work categories, multiply the factor weights and the stored cost/sf together to obtain an estimated cost/sf for the work category for this particular project. If for instance, the contributor had indicated a relatively light live load, normal spans and details, the estimated cost/sf would be $6.18 (.95 x 1.0 x 1.0 x $6.50).

4. Distribute the remaining portion of the total budget (after step 1) over the work categories without an assigned dollar figure in proportion to their estimated cost/sf.

Steps 5 through 7 are repeated for each work category.

5. Apply the labor percentage to find the labor dollars for the work category.

6. Distribute the labor dollars among the trades using the trade percentage distribution.

7. Distribute the trade dollars over the deciles of the job's duration using the decile distribution.

8. Aggregate the work category results for all the work categories to estimate the labor requirements for the entire project.

Two additional steps are required before the demand reports can be produced. First, the project must be located in time and the decile distributions converted to months. This is a relatively simple procedure. Second, the estimated labor dollars which will be expended in each month must be converted to their man-hour equivalents using the appropriate wage rates and effective dates from the WAGE RATE FILE.

Reports

Figure 8 is a sample demand report produced by this initial version of the job profiler. This one happens to be a Regional Report, but similar reports can be produced at any of four levels:

1. WORK CATEGORY REPORTS can be generated for any number of specified work categories.

2. INDIVIDUAL PROJECT REPORTS are developed by aggregating the work category estimates.

3. COUNTY REPORTS are aggregates of all the projects located in the county.

4. REGIONAL REPORTS are produced by adding together estimates for a number of specified counties.

Any or all of these reports can be specified in a single run.

The job profiler also has a line printer graphing capability for any of these reports, but this has not been used extensively because of the cost involved.

In Summary

BIDS is a computer based, regionally oriented construction information system designed to provide all segments of the construction industry with a better picture of future market conditions.

The current system, the one operating in the case study area, profiles projects in terms of their labor requirements and sums these for all projects operating in the region.

It is hoped that additional profiling capabilities will be added in the not too far distant future, particularly in the area of materials and contractor management capability.

20: PREDICTIVE MODELS: BUILDING SCALE

AN EXPERIMENT IN A COMPUTER-AIDED CONSTRAINT-ORIENTED APPROACH TO THE DESIGN OF HOME-UNITS

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Introduction

Considerable effort is today being expended in an attempt to understand how design proceeds and therefore we see the development of design processes or methods which either imitate or simulate a postulated procedure. During such operations the evolution of a suitable algorithm becomes paramount. However, in design we can often distinguish between two classes of parameters one of which is independent of the process or the model of the process: these are exogenous and endogenous parameters. Exogenous parameters are those parameters which can be considered to come from outside the process and are therefore not brought about or affected by the previous history of the simulation and are regarded as being determined outside the simulation. Endogenous parameters are those whose values are determined by the simulation and are therefore affected by its history.

It does depend on how we define the overall problem as to which parameters are exogenous and which are endogenous. In the extreme all values are endogenous but we tend to limit the applicability of our methods and models, hence we will always be faced with exogenous parameters. Generally, we accept exogenous parameters as constraints: such parameters might include the client's brief; planning regulations; financial restrictions; and a variety of physical conditions including material properties. We may categorise a design process as being exogenous or endogenous depending on its use of these parameters.

The purpose of this experiment is to examine a constraint-oriented or exogenous approach in the preliminary design proposals of multi-storey residential buildings.

Home-Unit* Design

(* Apartment or apartment building in American terminology).

We can examine the feasibility study and the development of outline proposals of home-units to determine which are the exogenous parameters.

Feasibility Study

Home-unit developers base their decisions on what and where to build on market research information. A developer will use maps of development areas showing where home-units have been built, are being built, and where the site zoned for units are. These maps together with demographic projections and with previous sales figures are used to guide his decision making.

Development Application

It is often at this stage that an architect is called to evolve a development application, i.e. an application made to the appropriate controlling body which supervises development in that area. The architect takes the developer's outlines and often simply perturbates them by investigating a number of possibilities within the regulations which govern development. Any solution which produces a specified minimum return and which satisfies the above regulations might be called a satisfactory outline proposal and forms the basis of a development application.

Exogenous Parameters

In the above process the only exogenous parameters are those indicated by planning codes which regulate development. Planning codes which might be applicable at this stage can be grouped as follows:

Protection of Public Health: these regulations are designed to produce minimum standards of daylight, sunlight and ventilation and are often for the protection of those around or near the building and necessarily for those within it.

Protection of Public Safety: these regulations are designed for the safety of the public in terms of such problems as the spread of fire from building to building, the effects on a building of an explosion within an adjacent building.

Protection of Economic Investment: since a building is an economic commodity these regulations are designed to maintain or control that economic base in relation to the apportionment of land costs to built area.

Protection of Service Systems: these regulations are designed to control the population on a site in relation to the various service systems, e.g. transport, power, waste disposal.

Provision for Public Amenity: these regulations are designed to produce public amenities on privately owned land.

All the other variables are endogenous and vary in each particular design problem.

The Constraints

Planning Codes

In this experiment it was decided to use the codes operating in North Sydney, one of the municipalities of the city of Sydney. Appendix One contains an outline of the relevant code, "Municipality of North Sydney Code to Control the Siting, Design and Erection of Residential Buildings". Appendix Two contains the section of the Local Government Act which provides a blanket set of rules throughout the city. Thus, these two sets of codes contain all the exogenous parameters used.

Examination of the regulations shows that they are procedure-oriented rather than performance-oriented and are based to a large extent on geometrical rules on the assumption that the proscription of the bulk or massing of the building will automatically satisfy many of the criteria discussed earlier. For our purposes these regulations have not been examined for any logical basis but have (at least at this stage) been accepted.

Problem Generated Constraints

In order to simplify the computational aspects we have introduced a number of our own constaints which we have considered as exogenous. Thus, in the work that follows these assumptions are made:

Site Shape: the site is rectangular; there is no material difference for irregular boundaries.

Accommodation: all solutions are limited to those cases where each storey of the building contains the same accommodation; this was done simply to reduce computation time, however, this situation tends to be the case in practice.

Economic Analysis: the economic analysis has been kept extremely simple, again to reduce computation time.

Data: we have used statistical data concerning circulation areas and car parking space requirements.

Production of Preliminary Design Proposals

The Procedure

With the exogenous parameters defined in the Appendices and those generated to simplify the computations we have a number of procedures available to us to produce preliminary design proposals using the endogenous parameters supplied by the developer. The problem now becomes essentially one of searching all configurations and combinations of the various types of accommodation generated within the exogenous parameters by the endogenous parameters. Two distinct procedures may be used for this:

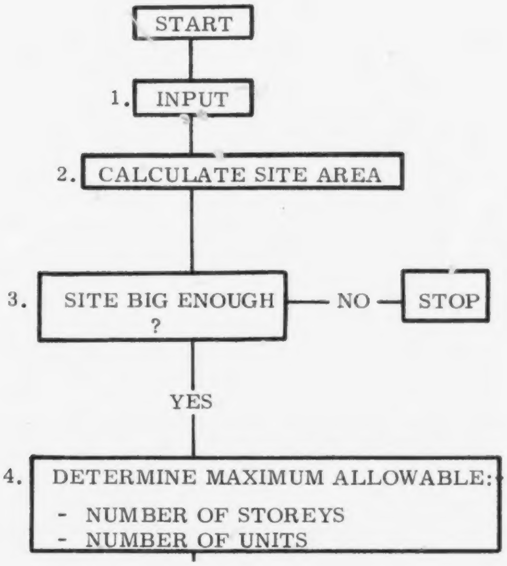
> Dynamic Programming: (Ref. 1) lends itself to be solution of precisely this class of problem; however, it is not well suited to allow the determination of sensitivities and also it is limited to a defined one dimensional objective.
>
> Iterative Search: provides a satisfactory alternative as we have a finite number of feasible solutions to search. In another context this method has been called design-analysis (Ref. 2). We generate a procedure which allows us to examine all feasible solutions.

The Computer Program

An iterative search algorithm was written around the exogenous parameters using the "Math +" compiler (Ref. 3) on an IBM Call/360 time-shared system.

Figure 1 shows the block flowchart for the program. A brief explanation of each of the operations shown in the flowchart is given.

PROGRAM FLOW CHART


START
1. INPUT
2. CALCULATE SITE AREA
3. SITE BIG ENOUGH ?
NO
STOP
YES
4. DETERMINE MAXIMUM ALLOWABLE:
- NUMBER OF STOREYS
- NUMBER OF UNITS

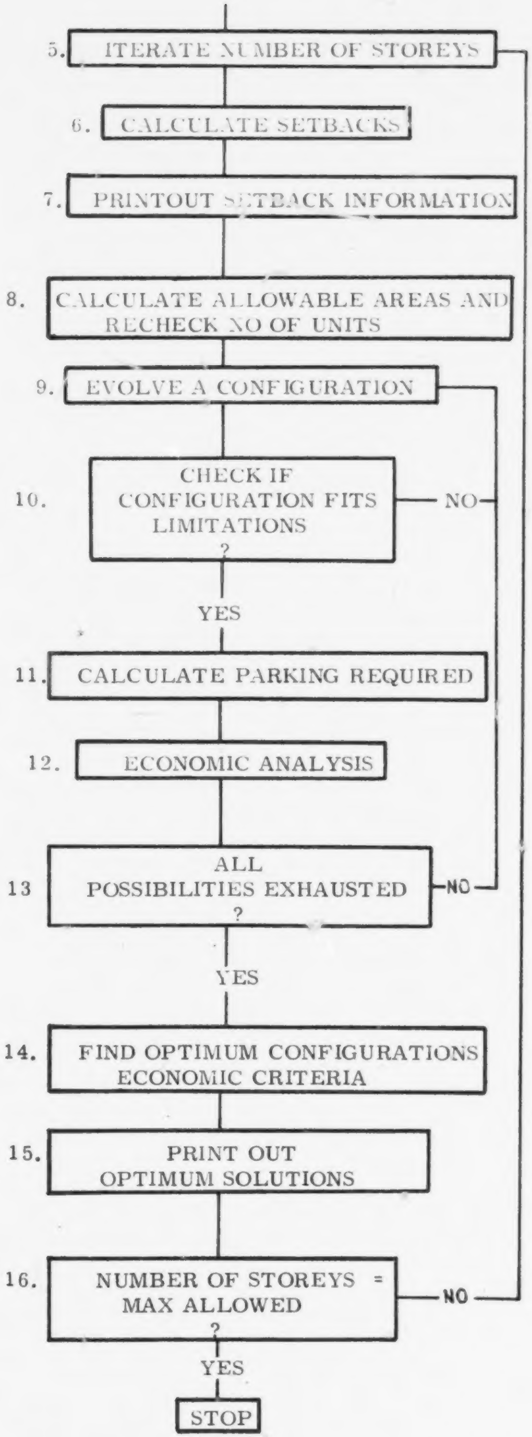

5. ITERATE NUMBER OF STOREYS
6. CALCULATE SETBACKS
7. PRINTOUT SETBACK INFORMATION
8. CALCULATE ALLOWABLE AREAS AND RECHECK NO OF UNITS
9. EVOLVE A CONFIGURATION
10. CHECK IF CONFIGURATION FITS LIMITATIONS ?
NO
YES
11. CALCULATE PARKING REQUIRED
12. ECONOMIC ANALYSIS
13 ALL POSSIBILITIES EXHAUSTED ?
NO
YES
14. FIND OPTIMUM CONFIGURATIONS ECONOMIC CRITERIA
15. PRINT OUT OPTIMUM SOLUTIONS
16. NUMBER OF STOREYS = MAX ALLOWED ?
NO
YES
STOP

Figure 1

1. Input. The following information is requested from the operator at the beginning of the program:-

(a) Site Dimensions.

(b) Site Zonings - i.e. on the North Sydney Code Maps 1, 2 and 3 these relate to densities allowable.

(c) The Building line.

(d) The distances of other buildings over 35 feet high from the site (this has relevance in determining setbacks).

(e) The standard of finish wanted. Here the operator can request simply luxury, Medium or Economy or he may present an actual dollar per square foot figure.

(f) The building income. The operator should feed in the rent or sale price that the units on this site can be expected to command. He is asked to give values for bed-sitters, 1 bedroom Units, 2 bedroom Units and 3 bedroom Units.

(g) Choice of Unit types. The operator has the option of choosing the percentage of 1 bedroom Units, 2 bedroom Units, etc. he wishes to have in the building. If no preference is indicated the program will compute all possibilities. If a preference is indicated (e.g. no percent of 2 bedroom Units) this will reduce the number of possible solutions and if preferences are given for all Unit types then only one solution for every number of storeys would be possible.

(h) Choose Unit size. The operator decides the area of each type of Unit.

(i) The cost of the site.

2. Calculate Site Area. With the present limitation to rectangular sites, this is a simple operation, i.e. Area = frontage/depth.

3. Is Site too small? The Code does not allow development on a rectangular site with an area less than 5,000 square feet or a frontage less than 50 feet.

4. Determine Maximum allowable number of storeys and Units. This operation corresponds to Part 2 of the North Sydney Council Code. Using the criteria of 1. Site Area, 2. Site Frontage, 3, Site Zonings, the maximum allowable number of storeys is found. Also, in some cases, a maximum allowable number of Units is found at this stage. (Subject to checking at a later stage).

5. Choose Number of Storeys. This stage of the program begins the iterative design process. It begins with a one storey building and consecutively increases this by one storey at a time to the maximum allowable in a "Do loop" operation.

6. Calculate Setbacks. This corresponds to Part 3 of the North Sydney Code. Using the criteria of 1. Site Dimensions, 2. Site Zonings, 3. Number of Storeys, 4. Proximity of adjacent buildings, the front, rear and side setbacks are calculated. Average and minimum setbacks are calculated.

7. Preliminary Output. Setback information for the current design is printed out at this stage.

8. Calculate allowable areas and number of Units. This operation corresponds with Parts 4, 5 and 7 of the Council Code. The site ratio is calculated as per Part 4 then as per Local Government Act Schedule 7 and the minimum is taken (using road widths as criteria). Site coverage is calculated using Zonings and number of storeys as per Part 5 and this and the site ratio are used to determine an overall allowable area for the building. A maximum allowable number of Units (N) is then arrived at using the site area as criteria (Part 7) and this value is checked against any previously calculated (N) values, the minimum one being retained.

9. Evolve a Configuration. The program will now systematically produce every conceivable combination of Unit types which sum to (N). If the input data has limited some Unit types to fixed percentages then the program will evolve only these combinations which suit these parameters and not every conceivable combination.

10. Check Configuration. Each configuration produced in Operation 9 is checked to see that it does not exceed the maximum allowable areas. Also, if the site is in area 1 on Code Map 3 the number of 1 bedroom Units must

not exceed 25% of the total and this is checked.

11. Parking. The number of spaces for resident and visitor parking and their areas are calculated (Part 6) for each combination which passes the checks in Operation 10.

12. Economic Analysis. Each design produced is now costed with the dollar per square foot figure fed in by the operator, or with standard values based on the building height and the standard of finish. The site cost is added to this.

13. End Loop. This is simply the end of the design iteration "Do Loop". The program returns to Operation 9 until twenty successful design configurations have been evolved.

14. Determine Highest Return Solutions. The twenty retained solutions are examined to find the five with the highest returns and these five are printed out. The procedure is repeated for each successive group of twenty produced.

15. Print Solutions. Each of the best solutions is then printed out, the following information being given:-

The numbers of each type of Unit (per floor and for the whole building).

The total number of Units (per floor and for the whole building).

The areas of each storey and the whole building.
The resident and visitor parking data.
The cost, income and return on the building.

16. End Loop. This ends the "Do Loop" testing different numbers of storeys. The program returns to Operation 5 to test different numbers of storeys.

Typical Output

Part of the typical output from the program is shown in Figure 2.

Discussion

To examine the constraint-oriented approach in the preliminary design of this class of building we formulated an iterative search algorithm around the exogenous parameters. The output from the resultant program indicates the usefulness of such an approach in providing "design envelopes" for a designer in such a way that he can distinguish between the effects of the endogenous variables and the constraints.

Such attempts are useful in a number of other ways - they can be used to examine the effects of changing the regulations and, indeed, could point to requisite changes in the regulations needed to produce better design solutions. As well they can be used simply to examine the validity of a particular solution with respect to the exogenous parameters and could, therefore, form the basis of a development application. Since most town planning codes are procedure-oriented this approach, considered only as a small segment of the overall design process, could prove to be of considerable value in eliminating "wrong paths" as well as providing pointers to certain directions. The program uses an economic criterion to select which solution to produce - this criterion could easily be expanded to include less explicit factors.

Work, using similar concepts, by Harper (Ref. 4) has shown that exogenous factors can be used to provide bounds for the feasible solution area which can then be examined in more detail. Steadman (Ref. 5) has applied graph theory to the generation of house plans taking the National Building Agency's Metric House Shells (Ref. 6) as the exogenous parameters.

The application of constaint-oriented design to performance specified systems, although considerably more complex, follows the same pattern. Further research is still required to relate the endogenous parameters to the performance constaints in such cases.

References

1. KAUFMANN, A. and CRUON, R.: Dynamic Programming, Academic Press, New York 1967. 278 pp.

2. GERO, J.S.: "Computers and Design". Computer Report CR11, Department of Architectural Science, University of Sydney, 1970.

3. HAGGERTY, M.I. et al: MATH (JOSS), ASDD Los Gatos Laboratory, CTS Papers 19, 20 and 21, April 1968.

(continued page 20-1-7)

```
Site Frontage = 90
Site Depth = 200
Area Zoning = 4
Density Zoning = 4
Unit Zoning = 1
Building Line = 25
Next you may choose a standard of finish OR a cost per sq ft value.
Standards of finish - Prestige 1=1 Medium 1=2 Economy 1=3 OR 1=$ per sq ft.
Standard of finish = 12
Sale price or rent per annum of bed-sitter = 0
Sale price or rent of 1 bedroom unit = 15000
Sale price or rent of 2 bedroom unit = 20000
Sale price or rent of 3 bedroom unit = 25000
Cost of Site = 25000
Front road width = 65
Side road width = 0
The values asked for next are the distances of adj bldngs over 35' high from the site.
If any of these distances is greater than 100' please put it equal to 100'.
Distance from side boundary of adj bldng = 100
Distance from side boundary of adj bldng = 90
Distance from rear boundary of adj bldng = 100
Next you may choose the desired %age of each type of unit.
If you have no preference put h = 200.
%age of bed-sitters = 0
%age of 1 bedrm units = 200
%age of 2 bedrm units = 200
%age of 3 bedrm units = 200
Area of Bed-sitter = 0
Area of 1 Bedrm unit = 800
Area of 2 Bedrm unit = 1000
Area of 3 Bedrm unit = 1200
                                    .... ............

SOLUTION 7
Number of storeys                              =  7
Minimum side setbacks                          =  15 and 15 ft.
Sum of min side setbacks                       =  30 ft.
Sum of average side setbacks                   =  50 ft.
Front building line                            =  25 ft.
Minimum rear setback                           =  15 ft.
Sum of average front/rear setbks               =  88 ft.
     B'SIT 1 BED  2 BED  3 BED  TOTAL  BLDNG    RESIDENT  VISITOR  BLDNG COST:BLDNG INC
     UNITS UNITS  UNITS  UNITS  UNITS  AREA     PARKING   PARKING  - BLDNG RETURN
                                       sq. ft.  car/area  car/area      $ =  $

A      0     0      0      2      2     2682    14 CARS   3 CARS   250288: 350000
B      0     0      0     14     14    18774    3500        750             40%
A      0     0      1      1      2     2459    14 CARS   3 CARS   231514: 315000
B      0     0      7      7     14    17210    3500        750             36%
A      0     0      2      0      2     2235    14 CARS   3 CARS   212740: 280000
B      0     0     14      0     14    15645    3500        750             32%
A      0     1      0      1      2     2235    14 CARS   3 CARS   212740: 280000
B      0     7      0      7     14    15645    3500        750             32%

 A = per floor                         ...................
 B = total building
```

Figure 2

4. HARPER, G.N.: "BOP - An Approach to Building Optimization". Proc. ACM 3rd National Conference, 1968, pp. 575-583.

5. STEADMAN, P.: "The Automatic Generation of Minimum-Standard House Plans". Working Paper No. 3. Land Use and Built Form Studies Centre, University of Cambridge, Cambridge, 1970.

6. NATIONAL BUILDING AGENCY: Metric House Shells, N.B.A., London 1968.

Appendix One

Municipality of North Sydney Code to Control the Siting, Design and Erection of Residential Buildings (Some Relevant Sections)

Part 1

The provisions of the Local Government Act, 1919, as amended, and the ordinances and the provisions thereof shall apply in all respects where hereinafter not provided for in this code, and no consent shall be given for the erection of a residential building, unless such building complies with the provisions of the Act and the Ordinances.

Part 2

8. (a) Except in the case of an allotment commonly known as a rear or battleaxe block, the minimum average width and the minimum area of an allotment upon which a residential flat building may be erected shall be as follows:-

(1) Where an allotment is within Area 1 (Foreshore) and all land coloured light green on Code Map 2 (low density areas) -

(a) In the case of a residential flat building containing two flats - average width 50 feet and area 5,000 square feet.

(b) In the case of a residential flat building containing four flats - average width 50 feet and area 7,000 square feet.

(c) In the case of a residential flat building containing more than four flats - average width 50 feet and an area of 9,000 square feet for the first five flats with an additional 1,500 square feet required for an additional flat with a maximum allowable total of flats in a residential flat building of six.

(2) Where an allotment is within an area shown as area 2 (Lower slopes), area 3 (Slopes) and area 4 (Plateau).

(a) In the case of a residential flat building containing two flats - average width 50 feet and area 5,000 square feet.

(b) In the case of a residential flat building containing not more than four flats - average width 50 feet and area 7,000 square feet.

(c) In the case of a residential flat building containing more than four flats -

(1) Where a residential flat building contains not more than two residential floors - average width 60 feet and area 7,500 square feet.

(2) Where a residential flat building contains not more than three residential floors - average width 60 feet and area 8,500 square feet.

(3) Where a residential flat building contains not more than eight residential floors (excluding any basement) - average width 70 feet and area 13,000 square feet.

(4) Where a residential flat building contains not more than ten floors (excluding any basement) - average width 85 feet and area 15,000 square feet.

(5) Where a residential flat building contains more than ten floors (excluding any basement) - average width 100 feet and area 20,000 square feet.

10. The minimum mean depth of an allotment upon which a residential flat building containing three or more flats may be erected shall not be less than 80 feet.

12. (a) The permissible number of floors under clauses 8 and 13 (b) hereof may be reduced for a particular allotment should the responsible authority consider such is desirable in the best interests of the amenity of the locality.

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(b) Where an allotment exceeds 10,000 square feet in area, the responsible authority may permit the number of residential floors to be increased over the number specified in relation to area of allotment in clause 8 at the rate of one residential floor for each 1,000 square feet in area the allotment exceeds the minimum area specified, subject to the provisions of clauses 8 and 13 hereof and provided the maximum number of residential floors does not exceed the maximum for the particular area as shown on Code Map 11.

Part 3

15. All residential buildings shall be set back from the side boundaries so as to comply with the requirements of sub-clauses (a) (b) (c) hereof:

(a) The sum of the average distances of a residential building from the side boundaries shall not be less than the aggregate calculated by the formula: $\frac{2W + 10F}{5}$ feet, where W = average width of allotment excluding any access strips, F = the number of floors excluding any cellar, as defined in Ordinance 71.

(b) The sum of the minimum distances of the building from the side boundaries shall not be less than:- 17'6" - one and two storeys, 25'0" - three storeys, 30'0" - four storeys and over.

(c) Notwithstanding the provisions of subclauses (a) and (b) of this clause, a residential building shall not stand closer to a side boundary than the distance prescribed in Schedule 7 of the Local Government Act for 'C' class residential flat buildings.

Proviso:-

Provided that no building shall be erected on land between the foreshore and the first street parallel thereto, with an overall width in excess of 50% of the average width of the allotment.

(d) The minimum distance between the walls of residential buildings exceeding 35 feet in height, excluding underground parking structures and ancilliary structures shall not be less than 100 feet.

15A. Subject to any building line as fixed by Council, the sum average distances of a residential building from the front and rear boundaries shall not be less than the aggregate calculated by the formula; $\frac{1\frac{1}{2}D + 10F}{5}$ feet, where D = average depth of the allotment excluding any access strips, and F = number of floors excluding any cellar, as defined in Ordinance 71.

Proviso:-

Provided (a) that for the purpose of calculations "D" shall not exceed twice the average width of the allotment, and (b) that the minimum aggregate front to rear distance so determined shall be added to the difference between the actual depth and "D" referred to in (a) above where the actual depth exceeds 2W.

Part 4

16. The maximum permissible gross floor area of a residential building shall not exceed one and three quarter times the area of the allotment, or that calculated in accordance with the provisions of schedule 7 of the Local Government Act, whichever is the lesser.

Part 5

17. A residential building shall not occupy more than the following proportion of the area of an allotment -

(a) Where an allotment is within Area 1 Foreshore) - One storey building 40%, two storey building 32%, three storey building 25%, four storey building 20%, five storey building 18%, six storey building 16%.

(b) Where an allotment is within an area shown as Area 11 (Lower Slopes), Area 111 (Slopes) and Area IV (excluding the areas coloured mauve - multi storey) - one storey building 40%, two storey building 35%, three storey building 25%, four storey building 20%, five storey building 18%, six storey building 16%, seven storey and over 15%.

(c) Where an allotment is within an area shown as Area IV and coloured mauve on the North Sydney Code Map 11 - one storey building 30%, two storey building 30%, three storey building 25%, four storey building 20%, five storey building 18%, six storey building 16%, seven storey and over 15%.

Note: 25% of all balcony areas to be taken into account when calculating the total floor area of flats and site coverage of residential flat buildings.

Part 6

18. Parking spaces, each 18 feet long by 8 feet wide shall be provided for the occupants of the building in the ratio of one car space per flat and for visitors in the ratio of one car space for each six flats or part thereof.

19. Such space as referred to in clause 18 above shall have access between it and a public road, street or lane unobstructed by other vehicles or vehicular parking spaces.

20. (a) The gross permissible coverage of the allotment, including the flat building, any appurtenant building and all paved areas, shall not exceed 60% and the remaining 40% of the allotment shall be landscaped to the satisfaction of Council.

(b) No detached garage building shall be in excess of one floor above ground level.

Part 7

21. The provisions of clause 36 of the North Sydney Planning Scheme shall be taken into account when considering an application to erect a residential building within the areas covered by the Code.

22. A residential flat building shall not contain individual flats with a floor area less than - in the case of a three bedroom flat - 1,000 square feet, in the case of a two bedroom flat - 800 square feet, in the case of a one bedroom flat - 500 square feet, in the case of a bed-sitting room flat - 400 square feet.

23. Density of Residential Buildings.

(b) Land content per Unit for residential flat buildings:- Town Houses 2250 square feet per Unit, 2 storey - 1000 square feet per Unit, 3 storey - 850 square feet per Unit, 4 storey - 800 square feet per Unit, 6 storey - 650 square feet per Unit, 7 storey - 575 square feet per Unit, 8 storey and over - 550 square feet per Unit.

Appendix Two

Local Government Act, 1919, as Amended

Schedule Seven. Classes of Residential Flat Buildings.

Class C.

The residential flat building shall not occupy more than the following proportion of the area of the allotment upon which the building stands:- in the case of a one storey building - 50%, in the case of a two storey building - 40%, in the case of a building containing more than two storeys - 35%. The total floor plan area shall not exceed one and one half times the total area of the site.

The minimum distance of the external walls of the first and second storeys from the side boundaries of the allotment on which the building stands shall be seven feet six inches; and the minimum distance of the external walls of any particular storey (other than the first and second) from the side boundaries of such allotment shall be ascertained by adding to seven feet six inches a distance of one foot six inches in respect of each storey additional to the second, up to and including that particular storey.

PACE 1 : AN ON-LINE DESIGN FACILITY

Thomas W. Maver

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Introduction

PACE 1 is an interactive computer program to be used for the appraisal of buildings at an early stage in their design. The package is the outcome of a year's work financed by a grant from the Royal Institute of British Architects and carried out by the Architecture and Building Aids Computer Unit, Strathclyde (ABACUS) at the University of Strathclyde's Department of Architecture and Building Science.

The Concept of Appraisal

Observation of the architectural design activity (1) has suggested a model, such as that represented in Figure 1, in which the sequential stages in the activity - Outline Proposals, Scheme Design and Detailed Design - each contain three processes - ANALYSIS, SYNTHESIS and APPRAISAL. Consideration of the role the computer might play in design (see ABACUS Occasional Papers 1 and 10), (2), (3) leads to the conclusion that the best pay-off will come from its application to the process of appraisal. Working in the traditional mode, the designer (or the designer team) carries out the process of analysis and, on the basis of this, conceives a design synthesis; at this point, rudimentary appraisal may take place. The process of appraisal is rudimentary because thorough appraisal is laborious, time-consuming and demanding in specialist skills. From the rudimentary appraisal, some modifications to the synthesis may be indicated and implemented but rather than undertake the onerous task of re-appraisal, it is likely that the designer will move immediately to the next more detailed stage in the design activity.

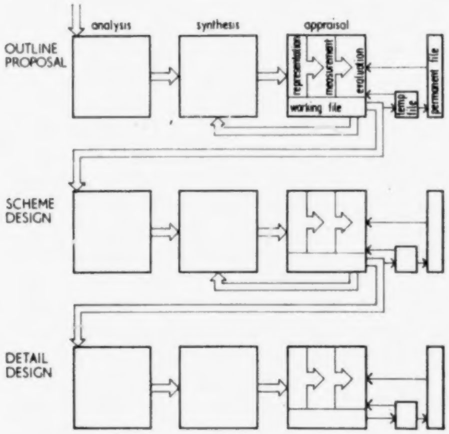


Figure 1

Few designers would deny the inadequacy of this mode of working; the inability to examine more than a very few alternative schemes at any stage and the conscious or unconscious failure to check all but what are arbitrarily considered to be the few most important aspects of the functioning of the scheme, makes adequate design, let alone good design, something of a lottery.

Hence the concept of a set of three computer appraisal packages - one for stage C (Outline Proposals) one for stage D (Scheme Design) and one for stage E (Detailed Design) in the RIBA Plan of Work which will allow the designer rapidly to appraise a large number of alternative schemes, each appraisal dealing with all quantifiable aspects of the scheme relevant to the current stage in the design activity. The main purpose of this paper is to describe the form and use of PACE 1, a general package for the Outline Proposals stage.

The Form and Use of PACE 1

PACE 1 (PACE = Package for Architectural Computer Evaluation) is designed to be used at the 'Outline Proposals' stage of the building design activity. The package is written in Fortran IV and runs on the time-sharing system operated by Systemshare Limited. Input is by means of a teletypewriter terminal and connection to the central processor is by means of GPO telephone lines. One pass of the program costs about $10.

As the input and output formats will show, the mode of interaction between the designer and the computer is 'conversational' with the machine taking the initiative. The responses from the designer may be typed directly onto the keyboard as the program runs, prepared beforehand on paper-tape which automatically feeds in data as required by the program, or written to file.

To illustrate the form and use of the package, a simple example will be taken. Consider a school building made up of 6 primary functional units (called components in the terminology of the programme). Figure 2 gives the relationship on a scale 0 - 10 between the functional units or components on whatever basis the designer considers appropriate. Figure 3 is the designer's initial conception of the scheme in relation to the site (Figure 4) with the volumes labelled in accordance with Figure 2. Components 1 to 5 are all rectilinear and can therefore be considered to be made up of only one element; component 6 is 'L-shaped' and is made up of two rectilinear elements - 6,1 and 6,2.

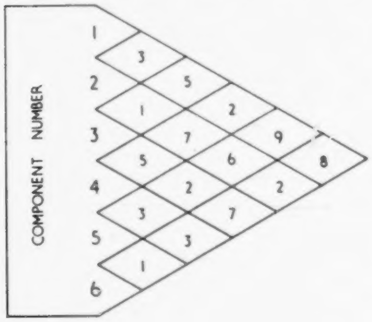


Figure 2

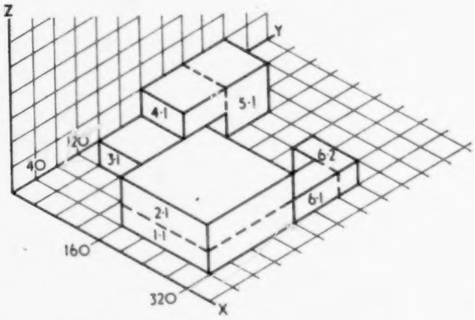


Figure 3

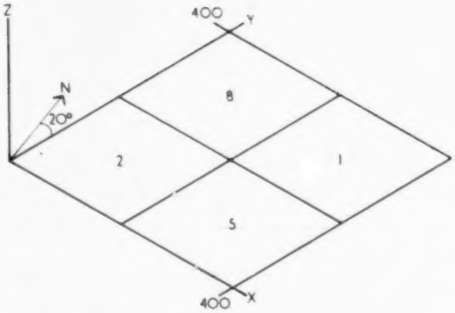


Figure 4

To carry out an appraisal of this design concept, the designer 'describes' his scheme to the machine as outlined in the following subsection.

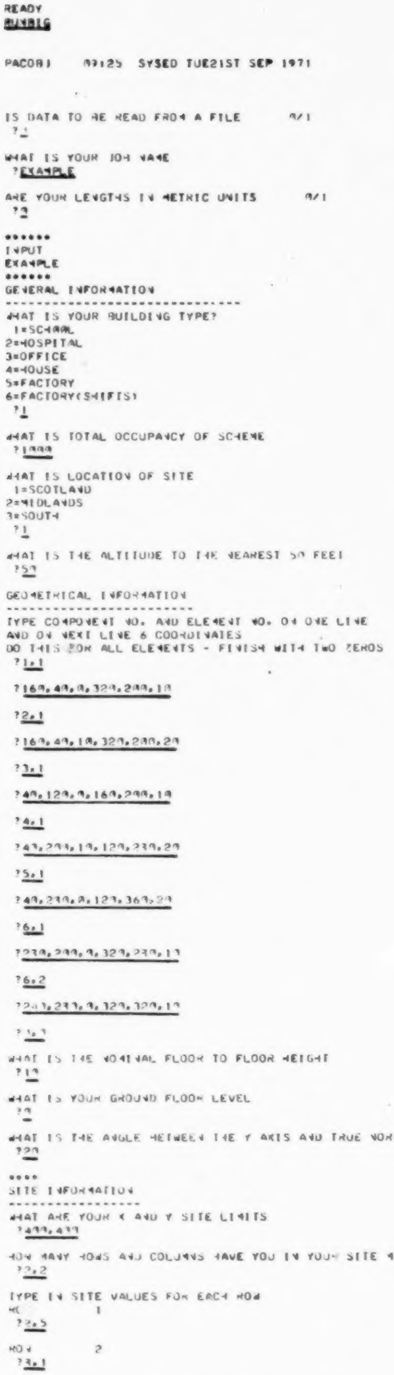
Input Format When the programme is called up (see Table 1) the computer prints the program name, the date and the time. It then asks the question.

```
ARE YOUR UNITS IN METRIC? 0/1
?
```

and waits for a reply to be typed on the keyboard by the designer. In this case the units are imperial and so the designer, in accordance with convention, types 'O' to indicate "No". (Throughout Table 1 the responses of the designer have been underlined for ease of interpretation.) The current version of PACE 1 operates in imperial units and produces the output in imperial units but, as implied by the first question, the machine will accept a metric input; a fully converted program is in the course of being written.

The input, as can be seen from Table 1, is in five sections - General Information, Geometric Information, Site Information, Constructional Information and Activity Information. These are dealt with in turn in the following sub-sections.

General Information: In this section the designer specifies the building type, the number of occupants, the location of the site and the height of the site above sea level. This allows the computer to access stored data on pattern of occupancy, recommended environmental standards and climate.



```
READY
RUNBIG


PACOBJ    09:25  SYSED TUE21ST SEP 1971


IS DATA TO BE READ FROM A FILE        0/1
 ?0

WHAT IS YOUR JOB NAME
 ?EXAMPLE

ARE YOUR LENGTHS IN METRIC UNITS        0/1
 ?0

******
INPUT
EXAMPLE
******
GENERAL INFORMATION
-----------------------------
WHAT IS YOUR BUILDING TYPE?
 1=SCHOOL
2=HOSPITAL
3=OFFICE
4=HOUSE
5=FACTORY
6=FACTORY(SHIFTS)
 ?1

WHAT IS TOTAL OCCUPANCY OF SCHEME
 ?1000

WHAT IS LOCATION OF SITE
 1=SCOTLAND
2=MIDLANDS
3=SOUTH
 ?1

WHAT IS THE ALTITUDE TO THE NEAREST 50 FEET
 ?50

GEOMETRICAL INFORMATION
-----------------------
TYPE COMPONENT NO. AND ELEMENT NO. ON ONE LINE
AND ON NEXT LINE 6 COORDINATES
DO THIS FOR ALL ELEMENTS - FINISH WITH TWO ZEROS
 ?1,1

 ?160,40,0,320,200,10

 ?2,1

 ?160,40,10,320,200,20

 ?3,1

 ?40,120,0,160,200,10

 ?4,1

 ?40,200,10,120,230,20

 ?5,1

 ?40,230,0,120,360,20

 ?6,1

 ?230,200,0,320,230,10

 ?6,2

 ?200,230,0,320,320,10

 ?0,0

WHAT IS THE NOMINAL FLOOR TO FLOOR HEIGHT
 ?10

WHAT IS YOUR GROUND FLOOR LEVEL
 ?0

WHAT IS THE ANGLE BETWEEN THE Y AXIS AND TRUE NORTH
 ?20

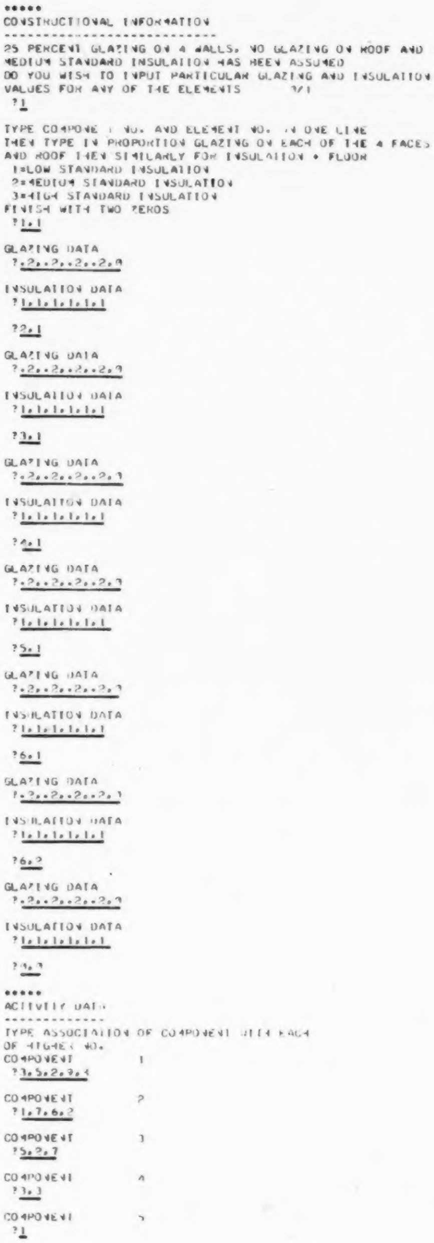
****
SITE INFORMATION
----------------
WHAT ARE YOUR X AND Y SITE LIMITS
 ?400,400

HOW MANY ROWS AND COLUMNS HAVE YOU IN YOUR SITE MATRIX
 ?2,2

TYPE IN SITE VALUES FOR EACH ROW
ROW        1
 ?2,5

ROW        2
 ?3,1
```

Table 1



```
*****
CONSTRUCTIONAL INFORMATION
--------------------------
25 PERCENT GLAZING ON 4 WALLS, NO GLAZING ON ROOF AND
MEDIUM STANDARD INSULATION HAS BEEN ASSUMED
DO YOU WISH TO INPUT PARTICULAR GLAZING AND INSULATION
VALUES FOR ANY OF THE ELEMENTS        0/1
 ?1

TYPE COMPONENT NO. AND ELEMENT NO. ON ONE LINE
THEN TYPE IN PROPORTION GLAZING ON EACH OF THE 4 FACES
AND ROOF THEN SIMILARLY FOR INSULATION + FLOOR
 1=LOW STANDARD INSULATION
 2=MEDIUM STANDARD INSULATION
 3=HIGH STANDARD INSULATION
FINISH WITH TWO ZEROS
 ?1,1

GLAZING DATA
 ?.2,.2,.2,.2,0

INSULATION DATA
 ?1,1,1,1,1,1

 ?2,1

GLAZING DATA
 ?.2,.2,.2,.2,0

INSULATION DATA
 ?1,1,1,1,1,1

 ?3,1

GLAZING DATA
 ?.2,.2,.2,.2,0

INSULATION DATA
 ?1,1,1,1,1,1

 ?4,1

GLAZING DATA
 ?.2,.2,.2,.2,0

INSULATION DATA
 ?1,1,1,1,1,1

 ?5,1

GLAZING DATA
 ?.2,.2,.2,.2,0

INSULATION DATA
 ?1,1,1,1,1,1

 ?6,1

GLAZING DATA
 ?.2,.2,.2,.2,0

INSULATION DATA
 ?1,1,1,1,1,1

 ?6,2

GLAZING DATA
 ?.2,.2,.2,.2,0

INSULATION DATA
 ?1,1,1,1,1,1

 ?0,0

*****
ACTIVITY DATA
-------------
TYPE ASSOCIATION OF COMPONENT WITH EACH
OF HIGHER NO.
COMPONENT        1
 ?3,5,2,0,4

COMPONENT        2
 ?1,7,6,2

COMPONENT        3
 ?5,2,7

COMPONENT        4
 ?3,3

COMPONENT        5
 ?1
```

Table 1 (cont'd)

Geometrical Information: The geometrical configuration of the scheme is input by typing in the coordinates of the two opposing vertices of each spatial element. The response 1,1 labels the element and the response 160,40,0,320,200,10 gives the x, y and z coordinates of the vertex nearest and furthest from the origin, as can be seen by reference to Figure 3; this simple input statement uniquely defines the size, shape and location of Component 1. The elements are entered in any order and the response 0,0 typed to indicate that this part of the input is complete. Additionally the computer requests information on the floor to floor height and the ground floor level (in relation to z = 0). The orientation of the scheme is input by giving the angle between the y-axis and the north point (Figure 4). It should be noted that no modular constraint is imposed by this form of input, unless specifically applied.

Site Information: The mechanism for describing the site to the computer is that of imagining a rectilinear grid placed over the site with a numerical value attached to each cell in the grid (see Figure 4). After inputting the overall dimensions of the site, the designer can specify how course or fine this grid is: for a uniform site the designer may specify, say, 2 rows and 2 columns; for a varied site he may specify a 20 x 30 grid. The actual values attached to the cells may be on any scale (in this case 0-10) and are input a row at a time, starting with the row adjacent and parallel to the x-axis (see Figure 3). It should be noted that the size of the site cells need bear no relation to the size of the spatial blocks input under Geometrical Information.

Constructional Information: This section of input allows information to be given about the proportion of glazing and the insulation properties of each face of each spatial element. If the designer wishes to waive this option, the machine will assume values on his behalf; thus if he answers 0 to the initial question in this section of the input the machine will inform him that, in this case, it will assume 25% area of glazing on all vertical surfaces, no glazing on horizontal surfaces, and medium standard insulation throughout. If he elects to input his own data, machine asks in turn for the glazing data and the insulation data for each element. A glazing data response of .2, .3, .4, .5, 0 indicates 20% glazing on the vertical surface nearest the x-axis, 30% on the vertical surface nearest the y-axis, 40% on the vertical surface furthest from the x-axis, 50% on the vertical surface furthest from the y-axis and zero glazing on the upper horizontal surface. An insulation data response of 2,2,2,2,1,3 indicates medium standard insulation on all four vertical surfaces (dealt with in the above order), low standard insulation on the upper horizontal surface and high standard insulation on the lower horizontal surface. It is important to note that the machine will take full account of horizontal and vertical interfaces between spatial elements and components; thus if component three abutts component one, the proportion of glazing on the relevant surface of component one will relate only to the un-adjoined surface.

Activity Information: The final section of input is the relationship matrix shown in Figure 2. The numerical values are typed in for each component in turn as can be seen by reference to Figure 2 and Table 1.

Output Format Table 2 gives the output format as it is typed by the computer. The output is in four sections - costs, spatial performance, environmental performance and activity performance. Before dealing with each section in turn, it is necessary to explain the three columns of numerical values. The first column headed "VALUE" is the absolute value measured by the computer in the appropriate units; the second column headed "UNIT VALUE" is a standardised measure, intended to be independent of size of the scheme; the third column headed "MEAN" is the mean unit value of all previously computed schemes of similar building type - of which more will be said later.

Costs: This first section of output deals with capital and running costs; the first column is in pounds sterling, the second and third column in pounds sterling per occupant. Capital cost and maintenance cost are computed by taking off quantities of floor area and surface area and multiplying by unit cost data held in file under each building type. Lighting and heating costs are obtained by multiplying the loads (described later) by the current unit energy costs which are held in file. When the designer chooses his fuel type, the hot water costs,

```
*****
OUTPUT
EXAMPLE
****

                                     VALUE     UNIT VALUE     MEAN
------------------------------------------------------------------
COSTS
------
CAPITAL COST                   $   432000.      432.0000    520.7000
MAINTENANCE COST/ANNUM         $     2951.        2.9512      3.3730
LIGHTING COST/ANNUM            $      397.        0.3972      0.5262
HEATING COST /ANNUM
-------------------
ELECTRICITY                    $     4139.        4.1396      5.4729
OFF-PEAK ELECTRICITY           $     3016.        3.0163      3.9939
GAS                            $     1473.        1.4731      1.9459
OIL                            $     1179.        1.1795      1.5596
ANTHRACITE                     $     1090.        1.0902      1.4236
DISTRICT HEATING               $     1439.        1.4390      1.9025
WHICH ENERGY DO YOU WANT          1-6
 ?3

HOT WATER COST/ANNUM           $      394.        0.3941      0.1340
TOTAL RUNNING COST/ANNUM       $     5995.        5.9955      6.3045
-------------------------------------------------------------
SPATIAL PERFORMANCE
-------------------
SITE UTILIZATION

SITE VALUE                                        0.3000      0.3399

PLOT RATIO                                        4.0000      2.7250

PLAN COMPACTNESS                                  1.3000      1.2599

MASS COMPACTNESS                                  0.5110      0.7131

                                                  0.4324      0.4273
-------------------------------------------------------------
ENVIRONMENTAL PERFORMANCE
-------------------------
X-SECT AREA RAIN WATER PIPE        544.        0.5440      0.4995
PERMANENT ART. LIGHT. REQD.      23600.       23.6000     35.8759
MECHANICAL VENTILATION REQD     472000.          472.        730.
HEAT LOSS/UNIT AREA                           29621.      27402.
TOTAL WATER STORAGE              10000.       10.0000     10.0000
SIZE OF HOT WATER CLORIFIER       1000.        1.0000      1.0000
SIZE OF BOILER                 4451615.    4451.6155   5754.3615
FOR HOW MANY COMPONENTS
DO YOU WISH HEAT GAIN/LOSS DIAGOSTICS
 ?2

WHICH COMPONENTS
 ?1,6

                            32371449.1
                            43194513.1
                            74965774.3
                            59543744.5
                            36146974.3
                           -17325555.5
                           -17146815.5
                           -16724967.5
                            36341946.9
                            43191997.7
                            71951713.3
                            73817396.5


                            39519219.7
                            39173943.7
                            3592[illegible]2.1
                            2749[illegible]39.9
                            17661246.1
                            -5629799.1
                            -5441329.1
                            -4765397.1
                            18627762.1
                            24271196.5
                            34722313.3
                            37933794.9


-------------------------------------------------------------
ACTIVITY PERFORMANCE
--------------------
MATRIX OF DIVERGENCES FROM MEAN
      1     2     3     4     5
  2  -.94
  3  -.14  -.31
  4  -.43  0.37  -.43
  5  2.19  1.12  -.64  -.74
  6  0.53  -.59  1.01  -.26  -.74
STANDARD DEVIATION                               0.99        0.28
DO YOU WISH TO CHANGE INPUT INFORMATION          0/1
 ?0

DO YOU WISH TO UPDATE FILE OF MEANS         0/1
 ?0

STOP
```

and hence total costs, can be output.

Spatial Performance: Spatial performance is measured by a set of ratio values, hence the fact that entries do not appear in the first column. Site utilisation is computed according to the traditional definition (i.e. the total floor area of the scheme divided by the site area), as is plot ratio (i.e. the total floor area of the scheme divided by the ground floor area). Plan and mass compactness are computed on definitions developed by the Building Performance Research Unit: plan compactness is defined as the inverse ratio of the plan perimeter to the circumference of a circle of equal area; mass compactness is defined as the inverse ratio of the surface area of the mass to the surface area of a hemisphere of equal volume. The remaining measure - site value - involves the numerical quantities attached to the cells in the site grid and is defined as the ratio of the average value of the cells covered by the scheme to the average value of all the cells on the site.

Environmental Performance: As opposed to actually measuring the environmental characteristics of the scheme, this section of the output essentially gives the sizing of plant which will result in adequate environmental conditions. The storm water piping is sized by taking account of roof area and stored information on maximum storm water precipitation. The area requiring permanent artificial lighting and the volume requiring mechanical ventilation are obtained by computing the floor area and volume of the central core a predefined distance from the outside glazed surfaces of the scheme. Sizing of the total water storage and of the hot water calorifier is achieved by applying the design recommendations in the IHVE guide, using stored constants and the information on the number of occupants which was output under General Information. Heat loss and gain are computed per hour for each spatial component and are based on

(a) stored information on hours of occupancy (which depends on building type);

(b) stored information on air change rates (dependent on building type);

(c) stored information on transmittance

coefficients (dependent on standard of insulation and proportion of glazing);

(d) stored information on indoor/outdoor monthly temperature differences (dependent on site location and altitude);

(e) stored information on solar gain factors (dependent on orientation of the four vertical surfaces, and area of glazing on each);

(f) heat gains from the occupants (dependent on number of occupants);

(g) lighting gains (dependent on volume of core and glazed periphery);

The boiler is sized on the basis of the maximum computed hourly heat loss. Apart from outputting the resultant heat loss per unit area, the program gives the designer the option of obtaining the month by month heat losses and gains for any number of individual spatial components; in the example given the losses and gains (gains identified by a negative sign), January through to December, have been output for components one and six. Throughout this section, with the exception of heat loss/unit area, the unit values, i.e. the values in column two of the output are obtained by dividing the absolute values in the first column by the number of occupants in the scheme.

Activity Performance: The final section of output provides measures of the degree to which the relationships input under Activity Information are satisfied by the proposed scheme. If the relationship measure in Figure 2, between components i and j is A_{ij} and the distance between these components in the proposed scheme is d_{ij}, then ideally A_{ij} should be inversely proportional to d_{ij}, i.e. the greater the relationship between two components, the closer together they should be. In other words, ideally $A_{ij}d_{ij} = k$, a constant. Since the magnitude of this constant will vary from scheme to scheme depending on the size of the scheme and the scale of relationship values, a standardisation is performed by computing the set of values

$$\frac{A_{ij}d_{ij} - \text{mean } A_{ij}d_{ij}}{\text{mean } A_{ij}d_{ij}}$$

and these are printed out in the matrix shown in the final section of Table 2. Since the ideal situation is represented by zero values in the matrix, it follows that a high positive value, as between components one and five, indicates that these two components have been located too far apart; a high negative value, as between components two and three, indicates that these two components have been located too closely together. To summarise this matrix, the standard deviation of the values in it are computed and output.

Three questions are asked by the computer at the conclusion of the output. The first invites the designer to change any of the input - the location of any component, the orientation, the areas of glazing, etc. The second question is applicable when the designer is satisfied that the scheme is a good one; by answering 1, all the unit values relevant to his scheme are used to modify, i.e. upgrade, the mean values stored from all previous schemes of similar building type. On subsequent use of the program, therefore, the mean values in column three of the output will be the most current available. The third question gives the option of obtaining perspective views of the scheme; if the designer answers 1, the computer produces paper-tape which, when fed into a graph plotter will cause eight perspective views to be drawn (Figure 5).

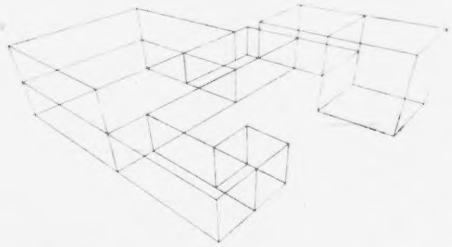


Figure 5

Use There are several ways in which the package can be used. The most obvious use is for the iterative modification of a design scheme to satisfy a particular brief. Another use is to compare alternative layout design strategies - linear, lattice, exocentric, etc. (4). A third use is the generation of the causal relationships between design variables : by systematically varying the input, keeping all variables constant except the ones under investigation, relationships such as that illustrated in Figure 6 between compactness and running costs, can be established from the output.

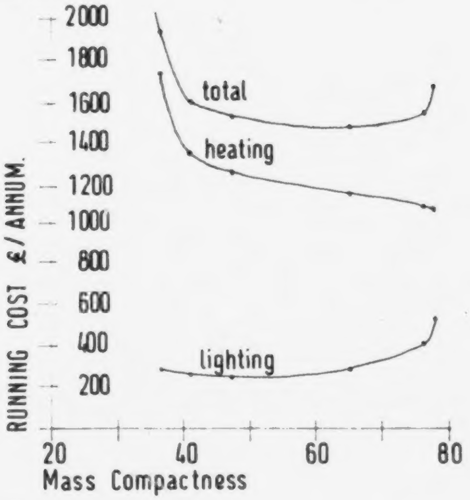


Figure 6

Future Developments

Developments and modifications currently in hand include

(a) amortisation of capital costs (based on an input of anticipated design life) to give an output of costs-in-use;

(b) a version working entirely in S.I. units;

(c) output of cut and fill based on an input of site ordinance levels;

(d) output of sun incidence on each face of each component, taking account of obscuring masses;

(e) a fourth column in the output giving the standard deviation of cost and performance data from previous schemes;

(f) a graphic version using a Tektronix 4010 direct view storage tube terminal;

(g) packages specific to schools, hospitals, housing;

(h) two further packages, PACE 2 and PACE 3, relevant to the next two more detailed stages in design

(i) an auto-modifying version of PACE 1.

Acknowledgements

The author wishes to thank the Royal Institute of British Architects for the faith it showed in sponsoring this work and Systemshare Limited (Edinburgh) for their generous disposition in the matter of payment for the computer time used. My colleagues in ABACUS and the Building Performance Research Unit have contributed substantially to the concept and implementation of this approach to computer-aided architectural design.

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JUSTIFYING DIAGNOSTIC RADIOLOGY AN ALTERNATIVE TO CONSENSUS PLANNING

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General

The task of planning, and designing efficient hospitals, of the correct scale and with the appropriate mix of facilities, is an immensely complex task, requiring the efforts of a design staff with special training and experience. It is unfortunately the case that few hospitals are designed under these conditions. Plans are often submitted which are deficient not only in the technical sense of providing insufficient space for a given facility but also in the economically significant sense of failing to provide the optimum scale and mix of facilities. Of even greater importance when considering capital expenditure for construction is the failing to provide for reasonable expansion and alteration possibilities of departments. Adequate information relating to future demands is generally the failing. The primary step in determining scale and mix is rationally measured need.

Given this situation, it would be desirable to have a set of formulae to provide guidelines to hospital planners and designers and to facilitate the review by government agencies of hospitals' plans submitted for State and Federal approval and support. The availability of such guidelines ought to reduce hospital construction costs in two ways. First, it would provide professional designers with information which they would otherwise have to obtain with costly duplication of efforts. Secondly, it would provide information for Federal and state review agencies which would help in identifying hospital plans that are rationally designed. Developing such guidelines in the form of a set of formulas based on a thorough knowledge of hospital planning and on a careful statistical analysis of capacity utilization factors is possible. The goal of the first phase of this research is to develop a small model, measuring one hospital department's needs. The The basic conceptual approach should apply to other hospital departments varying only in statistical detail. If the approach accurately reflects user needs, it will also apply to varying hospitals and regions. Information on the use of various facilities and on the size and type of staff would constitute the input to this model, and the output would consist of specific recommendations for the scale and mix of each type of facility.

Model Limitations

The model developed in this paper deals only with the expansion and/or replacement of existing diagnostic radiology facilities. The basic concept used relates to a department's utilization records and diagnostic room occupancy times for various procedures. This methodology makes no attempt to relate demand to the demographic characteristics of a hospital's catchment area which the author considers less definitive than actual utilization statistics as well as more difficult to correctly interpret. Since the next twenty years will see the greatest hospital construction needs in the remodeling-replacement area, rather than new construction, providing a rational yardstick for this kind of construction is not only appropriate but badly needed.

Programming in Retrospect

How to determine the scope and cost of new hospital facilities, the methods to be employed and particularly the degree of justification for them has become a growing concern not only to those professionals involved but to the general public who pays the bill. This is true not only of totally new facilities, but also of replacement or expansion of existing facilities.

In retrospect, much of the past hospital programming can best be described as "consensus planning," that is, a compromise consensus of those individuals directly concerned and available on the scene, often the Department Head and the Chief of Staff, with the Hospital Administrator serving as the adjudicator. Acceptance at face value of the space and equipment needs of the Department Head, however sincere his estimation process, can lead to a serious imbalance of facilities and fund allocation.

Problem

Neither the Hospital Administrator nor his professional consultant has any reliable standards for evaluating space and equipment requests. Reviewing agencies, from the hospital Board of Directors on up through the State and Federal Government have even less to use as yardsticks of reason. At best, they may have a department area guide which suggests overall departmental space as a percentage of total area or as a percentage of patient bed space. It has been accepted practive to approve department space programs which propose variations from such a guide providing mitigating circumstances exist and are persuasively delineated. The economic factors which might affect relative priorities for available funds are often left to chance.

Why Research Is Needed

Methods have been developed for evaluating needs and relative costs which appear excellent and quite valid; (1 & 2) however, these procedures require extremely involved, time consuming, sophisticated techniques not readily available to the administrator, the Architect, Board of Directors or review agency. To perform them requires a staff with special training and experience, including hospital Architects, a variety of consultants, cost estimators and medical economists.

Model Requirements

A tool is needed to help the planner in his determination of space need. Its characteristics should include the following as basic minimum criteria:

a. Simplicity in format.

b. Minimum of special knowledge required.

c. High degree of reliability.

d. Flexibility to permit adaptation to differing conditions without jeopardizing reliability.

Model Concept

The most obvious solution to this problem is to analyze the recent past history of need plus the other elements which influence total utilization time as a basis for projecting the future needs. This statistical approach appears to meet some of the above minimum criteria as applied to existing facilities, either to be replaced to expanded. Adaptability to differing conditions will be met by the number of influencing elements reflected in the model. Degree of reliability may be partially measured in terms of general acceptance in the model's "common sense" approach, though ultimately reliability will also be a function of recognizing the many elements influencing a particular need, correctly defining these elements and equating them to need.

It must also be recognized that medical doctors determine both inpatient and outpatient utilization of hospital facilities. This utilization is in a large part related to the expertise and personalities of the individual medical practitioners. However, unless unexpected shifts in geographical area of medical practice takes place, department utilization statistics provide an accurate yardstick to measure the total medical community's activity within the hospital department.

Problem Illustration

To illustrate the problem, let us examine the planner's difficulties in designing a Diagnostic Radiology Suite for a hospital of 200 beds to be expanded to 460 beds. There are many excellent sources of material produced by eminently qualified persons in private practice (3) and in government (4) describing all the various activities and functions of the suite, including the relationship of supporting activities and the department's relationship to other hospital departments. However, when the question is raised, how many diagnostic rooms shall be provided, programming usually reverts to "consensus planning," primarily because there is no quantitative yardstick available.

Example

A typical statistical analysis might take the following form:

a. Patients examined annually for the past year. 15,720

b. Number of procedures annually for the past year. 19,170

c. Number of diagnostic rooms. 4

d. Factored percentage of procedures done in regular working hours, i.e., percentage of procedures done during regular working hours, 65%, which must be factored to reflect relative time to accomplish procedures during off hours and those during regular hours.

A ratio of approximately 1 to 3 provides our estimate of the actual percentage of work time which should be delegated to regular working hours of 75%.

e. Percent of usable time, i.e., 90%. (Equipment " down time" for repairs -5%, -5% for scheduling dead time = -10%.)

f. Correction for unequal distribution of work load, i.e., 75%. (Daily work load variation factor, since the Diagnostic Room needs should be related

f. to peak load demands rather than average daily demands - 25%.)

g. Ratio of increase in beds, i.e., increased demand due to increased number of beds. (This assumes a constant inpatient and outpatient ratio.) 460/200

h. Regular work hours per year; i.e., room time required per procedure is assigned after averaging a sampling of each procedure type. Time includes transferring of patients in and out of a room, but does not take into account other dead time. Times are multiplied by the known number of procedures for each type for the latest year to arrive at an estimate of room time in hours per year. This number by the table works out to 7717 hours/year.

i. Number of regular working hours per week, 45.

DIAGNOSTIC RADIOLOGY

TABLE OF PROCEDURE TIMES

YEAR ENDING DECEMBER 1970

	No. of Exams Per Year	Minutes Per Exam	Total Hours
Head and Neck			
Facial Bones	130	20	43.2
Larynogram	4	60	4.0
Mandible	102	20	34.0
Mastoids	12	25	5.0
Nasal Bones	104	20	34.6
Neck for soft tissue	8	20	2.6
Optic Foramina	30	30	15.0
Paranasal Sinuses	68	20	22.6
Salivary Glands	8	30	4.0
Skull	980	30	490.0
Temporomandibular Jts.	16	30	8.0
	1,462		663.0
Chest			
Bronchography	36	60	36.0
Chest with Fluoro	104	40	69.2
Ribs	298	20	98.6
Routine chest	5,552	10	925.2
Sternum	40	20	13.2
	6,028		1,142.2
Spine and Pelvis			
Both Hips	30	20	10.0
Cervical	460	20	153.2
Discography	4	55	3.4
Lumbosacral	496	20	165.4
Myelography	60	60	60.0
Pelvis, Stereo	296	20	85.4
Sacrococcygeal	16	15	4.0
Sacroiliac Joints	8	20	2.6
Spots, detail, local	26	20	8.6
Thoracic	284	20	94.6
	1,680		587.2
Gastrointestinal Tract			
Air Contrast Barium Enema	156	60	156.0
Barium Enema	152	45	114.0
Esophagus	80	30	40.0
Intravenous Cholangiography	82	160	218.6
Oral Cholecystography	340	45	355.0
Small Bowel study	112	60	112.0

	No. of Exams Per Year	Minutes Per Exam	Total Hours
Gastrointestinal Tract (continued)			
Tube Placement	4	30	2.0
T-tube Cholangiogram	32	30	16.0
Upper Gastrointestinal with KUB	700	45	525.0
	1,658		1,438.6
Urological			
Cysto and Urethrocystography	24	60	24.0
Infusion Urogram	750	60	740.0
Intravenous Urogram	122	60	122.0
KUB	416	15	104.0
Nephrostogram	4	30	2.0
Nephrotomograms	56	90	84.0
	1,372		1,086.0
Gynecological and Obstetrical			
Hysterosalpingogram	4	60	4.0
Pelvimetry	24	20	8.0
	28		12.0
Upper Extremities			
Elbow	332	15	83.0
Fingers	412	15	103.0
Forearm	412	15	103.0
Hand	520	15	130.0
Humerus	116	15	29.0
Shoulders	516	15	129.0
Shoulders with Weights	8	20	2.6
Wrist	768	15	192.0
	3,084		771.6
Lower Extremities			
Ankle	688	15	172.0
Femur	120	15	30.0
Foot	666	15	166.4
Hip	328	15	82.0
Knee	522	15	130.4
Leg	304	15	76.0
Os Calcis (heel)	32	15	8.0
Toes	100	15	25.0
	2,760		689.8
Abdomen			
Abdomen, Complete Study	796	20	132.0
Miscellaneous			
Bone Age Studies	4	20	1.4
Bone Survey (without chest)	124	30	62.0
Fistula or sinus tract injection	12	60	12.0
Lower extremity venograms	6	60	6.0
Mammography	78	60	78.0
Scout for FB (Chest and Abdomen)	36	20	10.6
Tomograms (excluding nephro)	42	45	24.8
	302		194.8
Totals	19,170		7,717.2

Definitions

Number of Procedures Weekly = Annual Procedures ÷ 52 = 19,170 ÷ 52 = 368.1/week

Number of Procedures Daily = No. Procedures Weekly ÷ 5 = 368.6 ÷ 5 = 73.72/day

Number of Procedures per day per room = No. of Daily Procedures ÷ No. of rooms = 73.72 ÷ 4 = 18.43/day/room

Formula #1

$$\text{Number of Required Rooms} = \frac{\text{Current no. of daily procedures}}{\text{Number of procedures/day/room}} \times \frac{\text{ratio of increase}}{\text{in beds}}$$

$$\frac{73.72}{18.43} \times \frac{460}{200} = 9.2 \text{ Diagnostic Rooms}$$

Formula #2

$$\text{Number of Required Rooms} = \frac{\text{Room Time (hrs.) Current Year}}{\text{Regular Working Hours per Year}} \times \frac{\text{\% of total time used during reg.wk.hrs.}}{\text{\% of Usable Time}} \times \frac{\text{Ratio of Increase in Beds}}{\text{\% Corrections for Unequal Distribution}}$$

$$\frac{7717}{45 \text{ hrs.} \times 52 \text{ weeks}} \times \frac{.75 \times \frac{460}{200}}{.90 \times .75} = 8.39 \text{ Diagnostic Rooms}$$

Formula Analysis

From Formula #1, we determined that 9.2 or 10 Diagnostic Rooms will be required to perform the number of procedures to be expected from the hospital expansion, providing utilization rate remains constant.

From Formula #2, we determined that if the Diagnostic Room utilization rate can be increased to the optimum, the number of procedures can be performed in 8.39 or 9 Diagnostic Rooms.

Lengthening Time for Procedures

Both formulas used only data from the immediate preceding year. A more accurate analysis can be made if data from the previous five years is used as a demand indicator to verify or modify the above formulas. Stanley M. Wyman, M.D. of the Harvard Medical School, indicates that we should consider lengthening time for procedures due to their increased complexity (5) as well as increasing the number of procedures per patient. A careful study of the procedure times for the procedures listed in the table for each of the past five years indicates that the hospital studied experienced an annual increase in procedural times of approximately 4%. The same method as described herein was employed. Compounded over a five year period results in a five year increase in procedural times of 26.6% for the same identified procedures. Projecting this data ahead for five hears, we modify the Formula #2 accordingly:

Lengthening Time for Procedures (continued)

$$\frac{7717 + (26.6\% \times 7717)}{45 \text{ hrs.} \times 52 \text{ weeks}} \times \frac{.75}{.90} \times \frac{460/200}{.75} =$$

Required Diagnostic Rooms

$$\frac{9658}{2340} \times \frac{.75}{.90} \times \frac{2.3}{.75} = 11.3 \text{ Diagnostic Rooms}$$

On this basis, 12 Diagnostic Rooms would be required. There is of course no guarantee that procedural times or the number of procedures per patient will continue to increase at this rate. However, prudent planning would suggest the inclusion of at least five additional Diagnostic Rooms bringing the total to nine, and further to provide space in the master plan expansion for an additional three Diagnostic Rooms.

Comparative Analysis

The model described has been employed in justifying Radiology programming for one community hospital expanding from 245 beds to 500 beds and a university medical center major bed expansion. Neither project has been funded.

Conclusion

The method described requires considerable effort to provide an adequate time sampling of each type of procedure before an average time can be established. A fair and accurate

Conclusion (continued)
sample can be accomplished with a minimum training of personnel. Once this table of procedure time is complete, the verification of Diagnostic Room need becomes a simple calculation.

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21: PREDICTIVE MODELS: URBAN SCALE

COMPUTER-BASED SOCIO-ECONOMIC EVALUATION OF NEW COMMUNITY PROPOSALS

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NEW COMMUNITIES-HISTORICAL PERSPECTIVE

The institution of the planned community meeting the complete needs of its population for shelter, defense, economic cooperation, and social life may date to the first tribal groupings of men. As Jane Jacobs[1] has pointed out, the earliest known settlements in the Middle East were agricultural villages, providing a base from which the surrounding lands were cultivated. The modern history of new communities began when Ebenezer Howard[2], an Englishman, proposed the cohesive, independent economic entity represented by "garden cities" as the communal environment challenge to the congested morass of urban existence.

After Howard's initial communities of Letchworth and Welwyn, many new communities were developed in England under the New Towns Act of 1946, later modified in 1959. British new towns have attempted to offer an alternative to the previously singular choice of either suffering urban high density or long community distances from home to office[3]. There have been several rather notable accomplishments in the development of new towns in the rest of the European community. One of the best known of these is the Finnish new town of Tapiola, six miles west of Helsinki.

In the United States, new communities have evolved as the latest stage of planning sophistication beyond the already familiar "planned communities" which in a number of cases degenerated into suburban homogeneity. One of the early precursors of the new community in the U.S. was the company town--a by-product of profit-oriented industry interested in capturing its labor market by providing a planned residential benefit[4]. From the company town experience grew still another approach to planned communities: real estate communities. Motivated in their creation by a desire to isolate the residential sphere from the industrial process, these new communities seemed to take a slight bend from the philosophy of planned company towns.

It remained for Clarence Stein, a planner for the New York Commission for Housing and Regional Planning Association of America, to incorporate his vision of the planning process potential with the historical developments in American planning. The product was what is now referred to as the Radburn Idea. Stein was influenced primarily by Ebenezer Howard and Clarence Perry and their hypothesis that emphasized the neighborhood center as the structural component of new communities with accessibility provided by separate pedestrian and vehicular traffic routes.

THE NEW COMMUNITIES ACTS

The federal government has had varying roles in U.S. new communities until the establishment of the criteria for guarantees for financing new community land development as defined in Title IV of the Housing and Urban Development Act of 1968, later followed by Title VII of the Urban Growth and New Community Development Act of 1970.

Title VII provides for the development of a national urban growth policy with due consideration to environmental, economic, social, and aesthetic issues. Accompanying the projected population increase of seventy-five million persons and a general continuation of the current pattern of urban development, Congress identified a number of resultant effects which include:

- Inefficient and wasteful use of land resources;
- Increasing pollution of air and water;
- Costly and inefficient public facilities and services;
- Failure to make the most economic use of present and potential resources;
- Further lessening of employment and business opportunities for the residents of central cities;
- Separation of people within metropolitan areas by income and by race.

It is the hope that new communities will provide a possible alternative to these dismal projections. Title VII proposes financial assistance to those new community development programs which satisfy specified criteria[5]. These are abstracted below:

- Provide an alternative to disorderly urban growth.
- Be economically feasible.
- Contribute to the welfare of the entire area.
- Be consistent with comprehensive planning, physical and social.
- Contribute to good living conditions in the community.
- Make substantial provision for housing within the means of persons of low and moderate income.
- Make a significant use of advances in design and technology.

The following additional general criteria were spelled out in the Draft Regulations of July 28, 1971[6]:

- Be designed to create a newly-built community or major addition to an existing community which includes most, if not all, of the basic activities and facilities normally associated with a city or town.
- Must combine these diverse activities in a well-planned and harmonious whole.
- Must provide for the creation of a substantial number of jobs.

The federal criteria have now been imposed. It remains for an evaluation system to be structured in order to test the economic feasibility, the social cohesiveness, and the environmental characteristics of a proposed new community program to determine its eligibility for federal assistance.

ECONOMIC AND FINANCIAL FEASIBILITY OF NEW COMMUNITIES

Title IV and Title VII authorize the Secretary of Housing and Urban Development to guarantee or to enter into commitments to guarantee financial support for new community development projects.

Before making any commitments regarding financial guarantees for new community development, it is essential to evaluate the development plan for financing land acquisition and land development costs of the proposed new community and for improving and marketing the land. It must be determined whether this plan gives due consideration to the requirements under Title IV and Title VII and whether it represents an acceptable financial risk to the United States Government. Additionally, it must be determined that the internal development for the new community program is consistent with existing or proposed comprehensive master plans for the area in which the new community is to be situated. When the internal development and financing plans of the new community development project have been evaluated using the above criteria, it is then necessary to determine the economic feasibility of the program by analyzing the economic base and the growth potential, and evaluating the contribution that the new community will make to the orderly growth and development of the total area.

It is necessary to evaluate the new community development plan in the light of the general comprehensive area-wide plan for the entire region. The interactions between various external factors and the internal structure of the community must be examined. These external factors include population growth trends, major transportation facilities and development patterns, land use patterns in the entire region, infra-structure, employment opportunities in various different types of industries, the general environment, legal aspects, and political and social considerations.

The new communities planning process has been severely affected by the lack of adequate and representative information and by difficulties in quantifying inter-relationships and forecasting future trends in the community. The financial and economic feasibility of new communities is subject to a large number of external influences which have complex interactions with the internal aspects of the development plan. The need to develop a more complete analysis of both the financial and economic feasibility of new community development programs, which depend on many factors over which the developer has little or no control, was recognized by the New Communities Division of HUD.

The previously developed evaluation techniques, used by economic and market analysts, did not perform the required comprehensive evaluation of both the internal and external factors affecting new community development and the inter-relationships between these factors. In fact, most of the quantitative tools that have been used in the past for evaluation of new community development projects were basically accounting type models which arithmetically manipulated input provided by the model user to generate output regarding the internal financial factors for the community. These models were oriented only to the internal financial factors and failed to consider the structure of the emerging community and its relationship to the development of the region/area as a whole. The structure of the community, the support and service requirements were generally assumed to be known. These models were, therefore, unable to evaluate the economic, demographic, social, and industrial impact resulting from the new community development program.

In particular, the evaluation techniques suffered from the following weaknesses:

- The evaluation was based upon externally derived projections of housing and facilities requirements.
- The evaluation lacked adequate consideration of the dynamic structure of the community and its requirements under alternative planning assumptions.
- The models did not consider the basic community structure, housing mix, diversity, etc.
- The models were generally designed from the point of view of the developer.
- The present evaluation processes could not adequately compensate for the bias due to the optimism of the developer.

The New Communities Division of HUD, therefore, experienced a need to develop advanced analytical tools and models which will go well beyond the examination of financial feasibility in order to provide a full capability to assess the economic feasibility of new communities.

A research program was initiated to:

- Identify the important external factors which decisively contribute to the economic feasibility of a proposed new community development project.
- Develop a plan and program for implementing a capability to analyze the economic feasibility of new community development projects.
- Demonstrate the technical feasibility of implementing a full system for analyzing economic feasibility by drawing upon past experience and existing modeling tools and techniques.
- Develop a research plan that would lead to the development and implementation of improved new community evaluation models.

The major product of the research program was the basic NUCOMS[7] (New Community Simulator) system which was developed from the Community Model Subsystem and the Financial Policy Planning Subsystem to the PROMUS[8] program.

MAJOR ISSUES OF NEW COMMUNITY EVALUATION

There are three major aspects which must be taken into account in the evaluation process:

- Geographic Hierarchy: Region, Study Area, and Community

  The hierarchal approach of NUCOMS makes it possible to assemble and process a moderate amount of data at the regional level, and to progressively increase the degree of detail at each step so that the most complete analysis is carried out at the community level. In this way it is possible to represent all significant economic interactions and yet retain a manageable system.

- New Community Types: New Towns in Town, Satellite New Communities, and Isolated New Communities

  The requirements for evaluation of each of these significantly different new community types were analyzed and integrated with the hierarchal geographic approach indicated above. This approach makes it possible to utilize the same basic mathematical structure in analyzing each community type simply by appropriate definition of the geographic levels.

- Evaluation Stages: Pre-Application (Planning), Application (Development), and Post-Approval (Operation)

  A new community evaluation system must account for the varying availability of data and the needs for detailed outputs at each stage of the application process. By employing a modular system design approach, it is possible to meet these needs. In fact, the Basic NUCOMS system itself is a completely adequate tool for pre-application analysis and can provide considerable assistance in application evaluation.

Many other issues such as requirements for evaluating the developer's planning process, the relationships between physical planning and social planning, the proper role of advanced computer-based techniques relative to conventional analysis, and the possibility of predicting social indicators for the community were also analyzed and included in the evaluation system.

THE BASIC NUCOMS SYSTEM

The Basic NUCOMS System is comprised of three separate, but interlocking submodels, as shown in Figure 1. The first is the Small Area Submodel which predicts the change in population and employment by small area. The Neighborhood Submodel takes information on the policies of local governments and institutions, the changes in employment and population, and past socio-economic indicators to predict future socio-economic patterns. Finally, the Financial Submodel combines those small areas within the metropolitan region that constitute the New Community and computes income statements and cash flow statements for the developer.

The main purpose of the small area model is to project the spatial distribution and population and secondary employment given the spatial array of basic employment. The model is similar in structure to the Lowry model[9] and its modification by Crecine (TOMM)[10], but contains one major difference. Residential distribution is not made on the basis of distance or travel times as is the case with TOMM as well as most housing type models. The residential allocation process is based upon attractiveness indices. The attractiveness index measures the relative demand for housing in an area by employees working in another. The index is based partly upon travel time, but also includes relative land costs and site amenities. The attractiveness index can thus be made sensitive to the new community characteristics as controlled through the development plan.

At the present stage of development, it is necessary to employ independent estimates of the growth of the economic base. A major feature of the continuing research program is to develop methods for predicting overall regional economic development and industrial location in the new community from fundamental data.

APPLICATION OF BASIC NUCOMS TO EVALUATION OF PARK FOREST SOUTH, ILLINOIS

Using HUD and developer furnished data on the new community of Park Forest South, an analysis was carried out to determine the decision factors in residential capture from the surrounding areas, commercial development pace, revenue patterns, development costs, and cash flow projections (see Figure 2). Results were presented in the form of tabular computer output, as curves of output variables vs. time, and also by computer-generated maps. As an example, Figure 3 presents the results obtained from the base-case analysis of residential development pace. It is significantly different from the optimistic estimates of the developer who predicts a linearly increasing residential absorption. The NUCOMS model result shows a saturating pattern which is consistent with the fact that industrial development tends to slow down in later years, and also with general experience in urban development. A second example output is shown in Figure 4, which shows the cash flows produced by land development activities, and by all development activities including rental of industrial and commercial space.

Clearly, the land development cash flows support the development of revenue producing property which eventually accounts for as much income as land development. Inflation factors and the time-value of money were both considered in these studies. A final example of the system output is shown in Figures 5 and 6. These are computer generated maps showing the ultimate development of the sixteen township study area surrounding the new community, as well as the detailed development of the community itself. This presentation reflects the hierarchal geographic approach described above.

As part of the study, the effect of the new community on the surrounding region was estimated in terms of population gained (see Figure 7). A series of sensitivity runs were also made to evaluate the criticality of the assumptions. Figure 8 shows the effect of changing attractiveness indix for Park Forest South on the residential development pace.

SUMMARY

The primary purpose of the application of the Basic NUCOMS system to the Park Forest South new community was to provide insight into the strengths of the system relative to present evaluation methods. From a methodological viewpoint, one major advantage of a model structure is that the relationships among variables are explicitly represented. The relationships which influenced selected output results could be analyzed individually. Also, a computer based model permitted a rapid examination of the effects of alternative assumptions.

One of the most significant points made by the model was the internal consistency of results. A comparison of the results in ratio form, such as population per employee at Park Forest South and commercial employees per resident of Park Forest South, showed that NUCOMS produced a smooth and plausible trend over time while other independent estimates were erratic and inexplicable. The explanation is that the NUCOMS model considers the inter-relationships among variables rather than dealing with each estimate of development pace separately.

The second significant contribution of the NUCOMS approach is the ability to evaluate alternative attractiveness indices for the new community, thus allowing for the incorporation of many socio-economic variables in the analysis.

Another interesting point was the interaction of the new community with the surrounding region. Only about 50% of the employees who will work in Park Forest South were estimated to live there. This means that a strong industrial development pace cannot alone support rapid residential development. The loss of internal employment must be compensated by residents who will commute to jobs outside of Park Forest South. The growth of employment opportunities in the study area, particularly the adjacent townships, is vital to the sustained residential pace of the new community. The absence of strong growth for the adjacent townships to Park Forest South led to a lower residential demand than the developer anticipated.

A major advantage of NUCOMS over existing evaluation techniques is its flexibility and quick response capability. For example, a question was raised by HUD regarding the competitive effects of having another new community in Washington township (which is close to Monee township where Park Forest South is located). An analysis was conducted in a period of about only two days to evaluate the effects of such a new community on Park Forest South and surrounding regions and the estimates of the amount of growth taken away from Park Forest South by this new community were made (see Figure 9).

The development of the NUCOMS system and its application to Park Forest South have proved the feasibility and applicability of computer-based techniques for the planning and evaluation of new communities. Although the specific analyses described here related to evaluation of new communities by HUD, the NUCOMS system is equally useful to prospective developers for applications such as site selection, development planning and financial planning.

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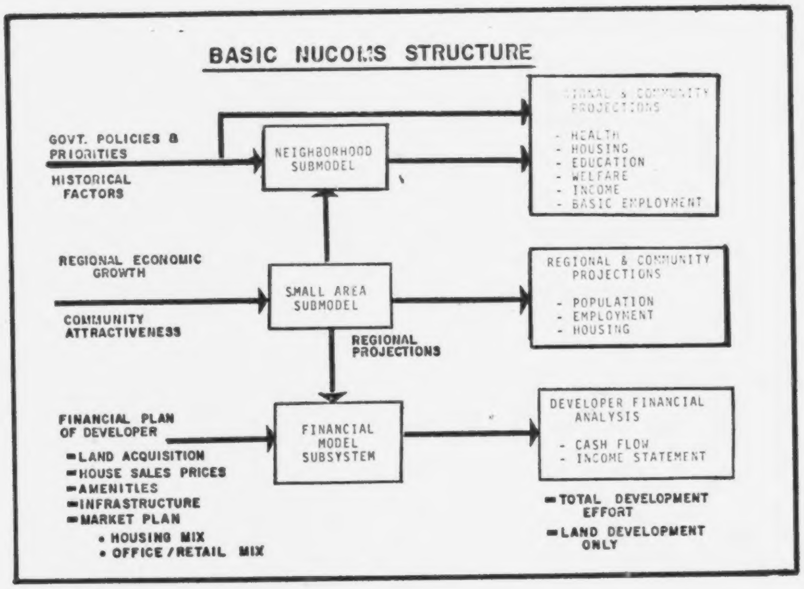

BASIC NUCOMS STRUCTURE
GOVT. POLICIES & PRIORITIES
HISTORICAL FACTORS
NEIGHBORHOOD SUBMODEL
REGIONAL & COMMUNITY PROJECTIONS
- HEALTH
- HOUSING
- EDUCATION
- WELFARE
- INCOME
- BASIC EMPLOYMENT
REGIONAL ECONOMIC GROWTH
COMMUNITY ATTRACTIVENESS
SMALL AREA SUBMODEL
REGIONAL & COMMUNITY PROJECTIONS
- POPULATION
- EMPLOYMENT
- HOUSING
REGIONAL PROJECTIONS
FINANCIAL PLAN OF DEVELOPER
-LAND ACQUISITION
-HOUSE SALES PRICES
-AMENITIES
-INFRASTRUCTURE
-MARKET PLAN
• HOUSING MIX
• OFFICE / RETAIL MIX
FINANCIAL MODEL SUBSYSTEM
DEVELOPER FINANCIAL ANALYSIS
- CASH FLOW
- INCOME STATEMENT
-TOTAL DEVELOPMENT EFFORT
-LAND DEVELOPMENT ONLY

FIGURE 1

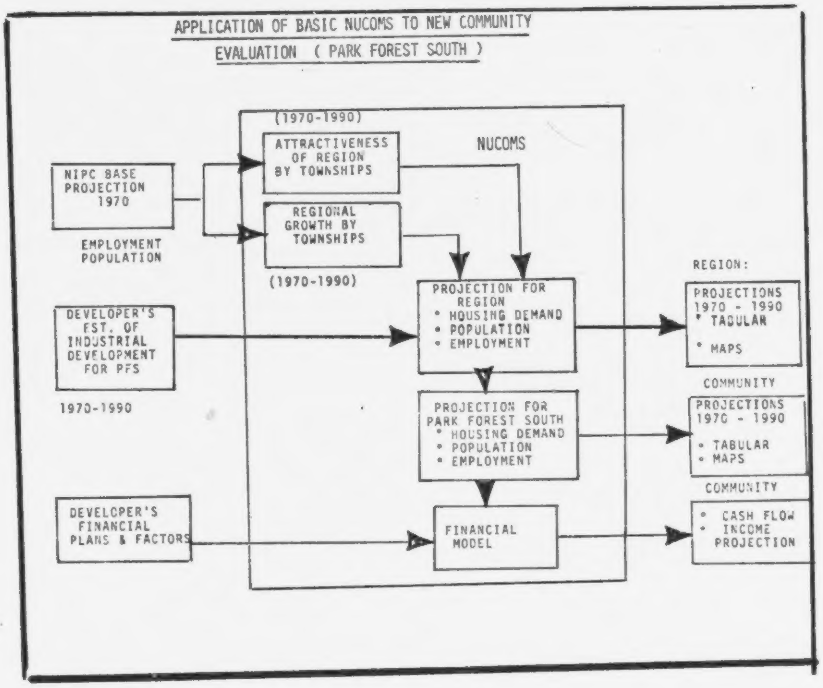

APPLICATION OF BASIC NUCOMS TO NEW COMMUNITY EVALUATION (PARK FOREST SOUTH)
(1970-1990)
NUCOMS
NIPC BASE PROJECTION 1970
EMPLOYMENT POPULATION
ATTRACTIVENESS OF REGION BY TOWNSHIPS
REGIONAL GROWTH BY TOWNSHIPS
(1970-1990)
DEVELOPER'S EST. OF INDUSTRIAL DEVELOPMENT FOR PFS
1970-1990
PROJECTION FOR REGION
° HOUSING DEMAND
° POPULATION
° EMPLOYMENT
REGION:
PROJECTIONS 1970 - 1990
° TABULAR
° MAPS
PROJECTION FOR PARK FOREST SOUTH
° HOUSING DEMAND
° POPULATION
° EMPLOYMENT
COMMUNITY
PROJECTIONS 1970 - 1990
° TABULAR
° MAPS
DEVELOPER'S FINANCIAL PLANS & FACTORS
FINANCIAL MODEL
COMMUNITY
° CASH FLOW
° INCOME PROJECTION

FIGURE 2

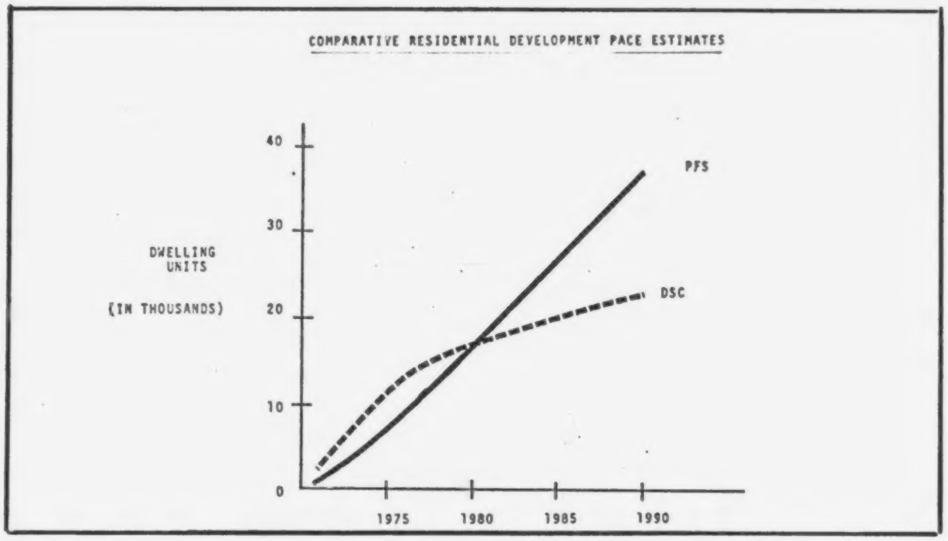


FIGURE 3

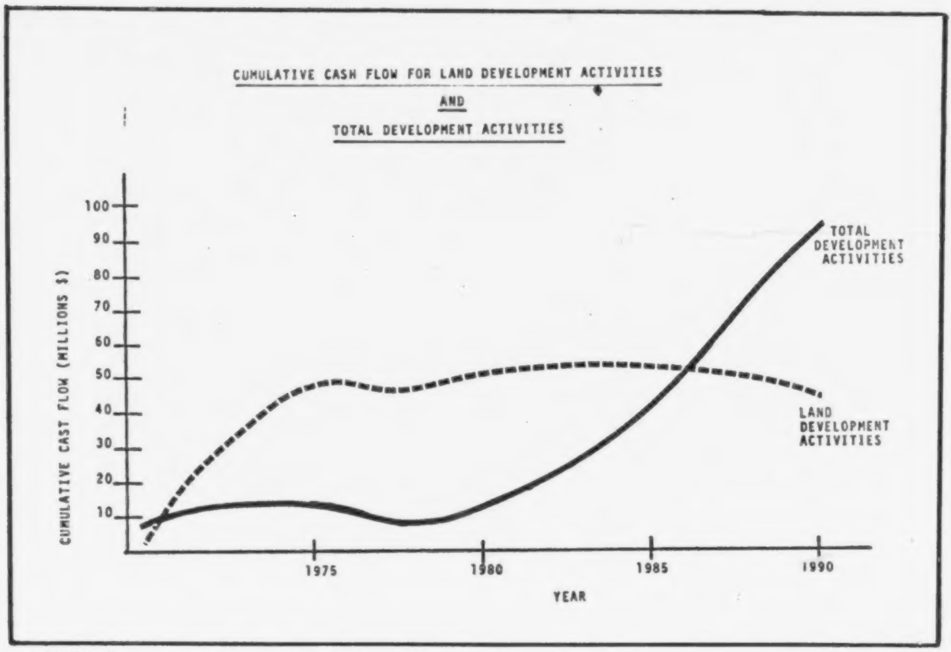


FIGURE 4

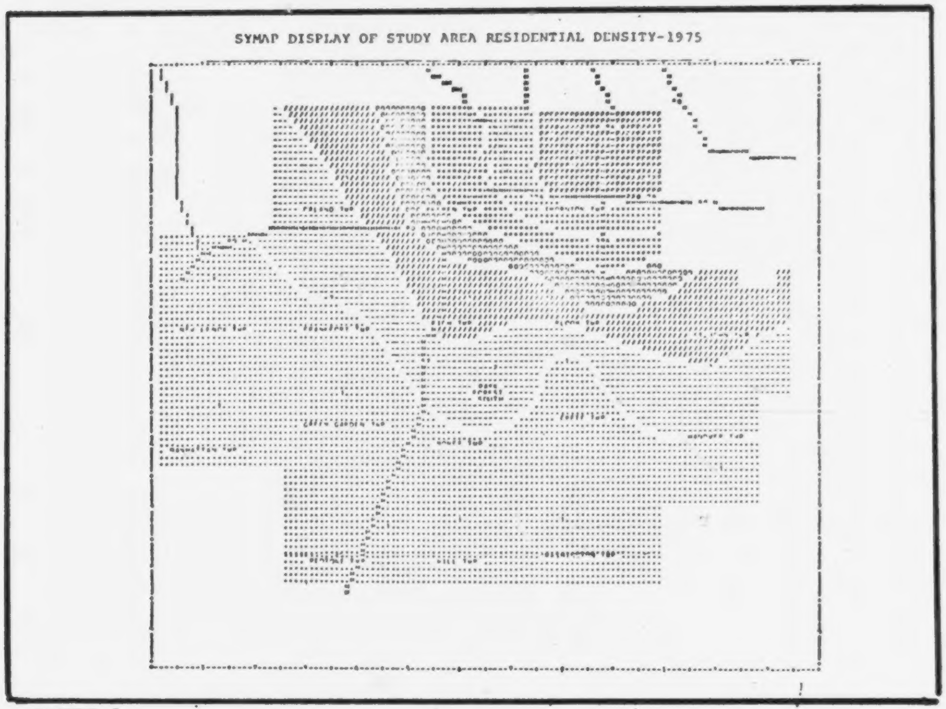

SYMAP DISPLAY OF STUDY AREA RESIDENTIAL DENSITY-1975

FIGURE 5

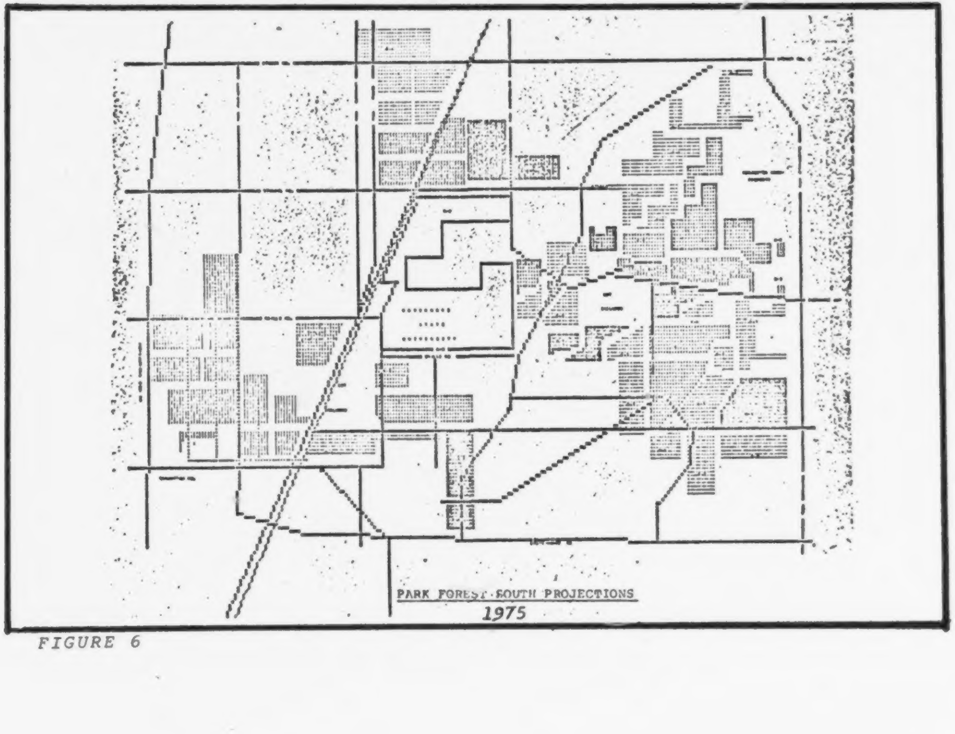

PARK FOREST SOUTH PROJECTIONS
1975

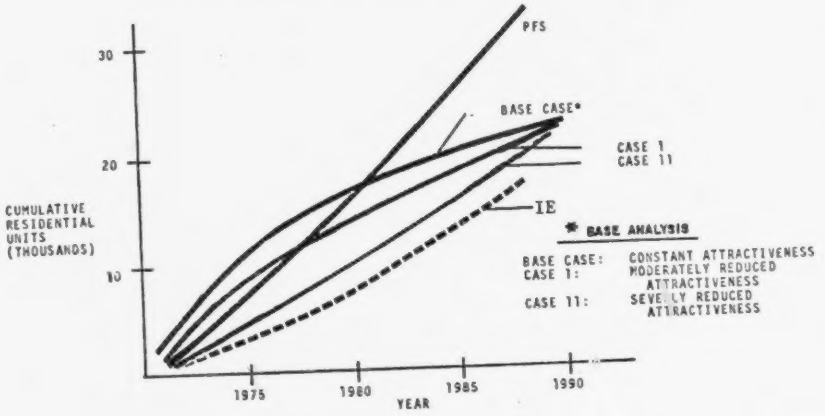
FIGURE 6

EFFECTS OF NEW COMMUNITY ON POPULATION OF ADJACENT TOWNSHIPS BY 1990

TOWNSHIP	ADDED POPULATION
Frankford	4,750
Rich	4,000
Bloom	negligible
Green Garden	2,300
Monee	46,000
Crete	3,100
Peotone	1,600
Will	4,700
Washington	5,200
Remaining	16,000

FIGURE 7

EFFECT OF DECREASING ATTRACTIVENESS INDEX FOR EARLY YEARS ON RESIDENTIAL PACE

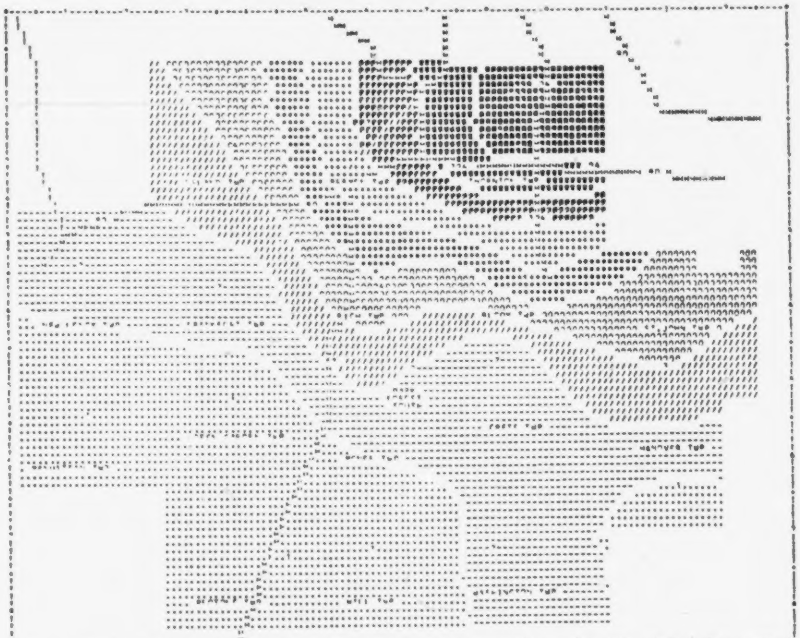


Notes:
PFS - Park Forest South Developer Estimate
IE - Independent estimate made by economic consultant

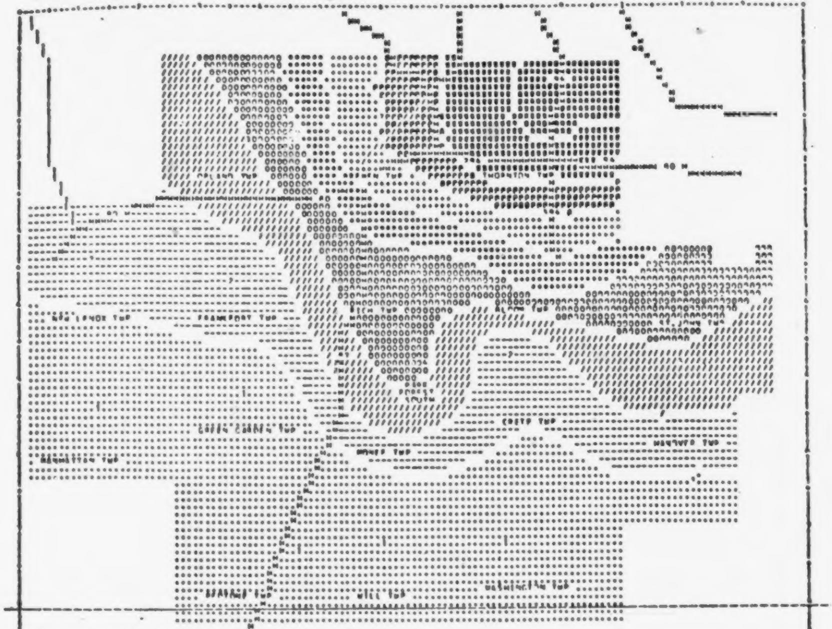
FIGURE 8

STUDY AREA POPULATION DENSITY PROJECTIONS

(showing effect of competing new community in Washington Township)



A. Park Forest South plus New Community in Washington Township



B. Park Forest South alone

FIGURE 9

LAND USE CONTROLS: DEVELOPMENT IMPACT MODEL

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For the past few years we have been interested in the potential use of mathematical models in making land development decisions. As private land planning consultants to both project developers and municipalities we have had to provide an increasingly broad range of services in order to effectively package the information necessary to approach rational decision-making. Our tentative conclusion at this stage is that a conglomerate model which can effectively evaluate the consequences of the development process is not only possible but essential.

The sub-models which presently exist in various stages of sophistication are ultimately useful only to the extent that they relate to each other in terms that enable people to make decisions. By focusing on output as it relates to physical, social and economic systems, we have been able to identify at least in a theoretical way how existing sub-models must relate to each other. In the process we have naturally found substantial voids in the present state of the art. Specifically these are in two general areas: environmental protection and political (legal) implementation. Actually these two areas of concern are related.

It has been demonstrated at this conference and elsewhere, that there is no great difficulty in evaluating market demand, financial feasibility and the fiscal impact of development projects on municipalities. Basically it is possible to simulate the effects of alternatives because costs and revenues can be reasonably estimated. Granted that market models are gloriously oblivious of fundamental human needs and that cash flow models are not directly helpful in the crucial task of appraising risk; but perhaps these questions are more appropriately reserved for later analysis when some semblence of order has been brought to modeling the overall development process.

The assumption is, and we believe it is a reasonable one, that if output demand from a market model is expressed in terms of land use development pace and price allocated to a specific location, the physical attributes of that location such as buildable land and utility services can be designed to fit demand. The resultant site plan can be evaluated for both private and public feasibility; private because the variables are well defined and public because the service demand in terms of roads, utilities, schools and other local services have defined costs although changes in levels of service over time are policy determinations which are more difficult to predict.

The crucial variables which link the economic models with the physical plan are not difficult to identify. Is there enough effective regional market demand and can this demand be aggregated at the specific location? At what average price level can both private and municipal costs be amortized?

Other than the fact that these models are not generally linked, there is no theoretical difficulty with the procedure described above. We spent nearly a year fantasizing about how much better land planning would be with this capability until we realized at least two grave difficulties. One was that there was no effective top to the system in urban regions where market demand approaches a free resource. It economically benefits both the developer and the municipality to increase density even though the net benefit is on a diminishing basis. The impact on environmental quality, however, is inversely proportional. Further, how do you legally differentiate on the basis of health, safety, and welfare between political reluctance to accept a fair share of social need and a valid restriction on the use of environmental resources which respects private property rights? Whatever measures are adopted must be capable of uniform and reasonable application if they are to stand judicial review.

For these reasons, while we are using economic models, we have concentrated our efforts on establishing a legal environmental limit. If the economic models establish a minimum feasible position for both public and private action, maximum permissible land use will have to be defined by environmental controls. Definition of an allowable range of land use intensity will eliminate the need for fixed zoning controls which have been increasingly ineffective in land use management. On the other hand, procedures for negotiated land use such as Planned Unit Development must be properly controlled so that municipal officials have a reasonable basis for decision.

Our experience indicates that although most public decisions are obviously economic, the courts have steadfastly refused to accept economic evidence looking instead to comprehensive community policy and procedural rigor as tests of equity. Our assumption at this point - without benefit of a test case - is that an environmental control supported by public policy statements can be used to uniformly and reasonably limit land use intensity. This assumption is supported by decisions sustaining floodplain zoning, and by a recent decision in New Jersey (Oakwood at Madison v. Township of Madison, October 27, 1971). In Madison, the court held that ecological data could justify zoning in the context of comprehensive public policy to protect the general welfare.

The technical assumption implicit in this work is that if disruption of the hydrological cycle is controlled within tolerable limits, the natural systems will be able to maintain a reasonable level of quality indefinitely. This restriction, however, must recognize private property rights which are constantly being redefined by the courts. We have tentatively accepted recent decisions of the Pennsylvania Supreme Court which has indicated that 1 dwelling unit/acre is the most restrictive zoning classification which the courts will recognize as non-confiscatory. (Appeal of Kitmar Builders, Inc., 439 Pa. 466, 1970.)

The procedure which we have developed and applied produces a numerical output table which can be mapped for use and delineated for display. Each grid cell receives a % designation which is the maximum impervious cover which can be placed in that location. The following procedural outline describes the method by which this task is accomplished:

Coverage Model:

The Water Budget
The water budget of a drainage area refers to the disposition of the annual precipitation.

1. Interception Moisture retained on the surfaces of leaves, rocks, etc. and evaporated directly.

2. Direct Runoff Water running directly into streams without soaking into the ground.

3. Infiltration Precipitation which is not lost to interception and direct runoff infiltrates into the ground at a rate which is a function of the type of ground cover and soil characteristics.

4. Evapotranspiration A portion of infiltration is transpired by plants from roots to leaves and hence evaporated.

5. Base Runoff Infiltrated water moves through soil and bedrock and enters the surface drainage system as base runoff from springs. A portion is extracted from wells for human use, but most of this is returned to surface drainage. Base runoff fluctuates seasonally.

6. Hydrologic Response HR is direct runoff in inches divided by annual precipitation in inches. High values indicate storm drainage problems.

7. Peak Discharge A measure of water flowing past a control point. This is a measure of the effect of runoff, while the direct runoff equation analyses the cause of runoff.

Runoff Computation

1. Direct Runoff To compute direct runoff for any given storm we have chosen the method devised by the Soil Conservation Service (SCS), which is explained in detail in Chapter II of the SCS Field Manual and the SCS National Engineering Handbook: Section 4, Hydrology; Part I - Watershed Planning, Chapters 7 - 11.

a. The equation in working form is

$$Q = \frac{(P - 0.2S)^2}{(P - 0.8S)}$$

Where:
Q = Direct runoff in inches
P = Precipitation in inches
S = Maximum potential retention in inches

b. In the above equation S varies with soil type and ground cover. The first step is to determine the soil type and to place it in one of the four categories used by SCS. These categories are:

- High infiltration capacity.
- Moderate infiltration capacity.
- Low infiltration capacity.
- Very low infiltration capacity.

c. Normally, four classifications of ground cover are adequate:

- Forest
- Meadow
- Lawn
- Impervious

d. Each combination of soil group and ground cover is assigned a curve number (CN) by the SCS manuals. This CN must be adjusted for antecedent moisture condition (AMC). SCS tables serve to adjust CN to three classes of AMC, principally as follows:

- AMC I. Dry period before the given storm.
- AMC II. Normal precipitation before the given storm.
- AMC III. Heavy rainfall, saturated or frozen ground before the given storm.

e. Given an adjustment for AMC, the SCS tables convert CN to S. Given P and S, solve for Q; direct runoff for a given storm.

2. Annual Direct Runoff

a. The above equation should be applied to each rainstorm for a one year period for each CN encountered on a given site.

b. Annual rainfall patterns can be determined from U.S. Weather Bureau records for a period of 10 to 20 years, and a value for P determined on that basis. Use values of S corresponding to each CN condition found on the site.

3. Effect of Impervious Cover

a. To determine the direct annual runoff resulting from development solve for Q in both the predevelopment and postdevelopment conditions.

b. The postdevelopment condition can be simulated by a curve number CN', which is the weighted average of the percentages of the site with predevelopment curve numbers and the percentage with impervious cover, where CN = 98.

c. However, the increment of direct annual runoff by itself is not an adequate measure of the impact of development on the hydrologic system. Topography must also be considered. Although slope does not determine runoff, it does affect peak discharge and consequently erosion, siltation and flood hazard.

d. We, therefore, add an adjustment for slope to base our increment on peak discharge. Slope categories of 0-3%, 3-8%, 8-15%, 15-25% and 25%+ are considered.

Limiting Impervious Coverage

1. An acceptable increment of annual direct runoff and peak discharge must be established. Based on this increment, we can calculate the percentage of impervious cover which will produce that increment for each CN condition.

2. For our work in Pennsylvania we have used the increment produced by an FHA minimum standard single family development at a density of one dwelling unit per acre, on the worst combination of soil, vegetation, and slope. This judgement is based on the recent Pennsylvania Supreme Court cases, which seem to indicate that restrictions beyond one dwelling unit per acre would be confiscatory.

Necessary Research - Performance Standards

1. The need for performance, rather than fixed standards is due to the observation that a specific runoff standard may limit development to a point where essential housing goals for a given area cannot be achieved within the economic constraints of the private market and the public service cost. Performance standards would allow greater densities and greater increments of impervious cover when site improvements such as ponding, swales, dry wells, etc. were used to compensate for the increased allowable.

2. Determination of performance standards raises problems which fall into two basic categories:

   a. Measures for simulation of the effects of retention ponds, grassed swales, dry wells, french drains, ground water recharge basins and other site improvements.

   b. Determining a reasonable performance standard within legal parameters that can be uniformly applied.

We anticipate a program of continuing basic research to support the use of the Coverage Model proceeding in two directions: legal application through implementation devices such as zoning ordinances and development codes and supporting documentation of the hydrological effects of urbanization.

Our present objectives in using the Development Impact Model are to refine and simplify the links between economic sub-models, physical plans and the coverage model so that evaluation time and costs can be reduced to the point where the system can be employed for smaller projects. We are hopeful that the ultimate effect of our work will be a better distribution of resources brought about by providing rational tools for political decision making. It appears to us for instance that the process of land utilization is a major element in dealing with the problem of housing.

A DEMONSTRATION OF THE USE OF COMPUTER-AIDED LAND-USE MODELING FOR REGIONAL SERVICE SYSTEM DESIGN

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Introduction-Project Background

As has repeatedly happened in the recent past, advances in certain military and purely technological sciences have eventually become recognized as having applicability to civilian life or, more specifically, to the urban situation. More precisely, two spectacular developments have been found particularly attractive for conversion into urban technology. The first is the impressive development of computer hardware, and the second is the somewhat parallel trend toward systems methodology as it first emerged in the space and defense industries.

We all know that the reasoning went somewhat like this: "If we can get a man to the Moon, we should be able to do something about our current urban problems using the same expertise, intelligence, methods and techniques." A number of things have been done in this direction by individual firms, universities, agencies and persons, but somehow there has not been any kind of effort that could even remotely be characterized as massive or comprehensive.

An exception to his, however, may be the program initiated by the U. S. Department of Housing and Urban Development under Section 701 (b) of the Housing Act of 1954, as amended. This program, the Urban Systems Engineering Demonstration Program, provides Federal assistance of up to 2/3 or 3/4 of the costs for projects in the urban field that utilize systems and computer technology. Public bodies having authority for planning areawide systems of public facilities and/or services are eligible to initiate and conduct such projects. Preference was given to regional scale water supply, sanitary sewer and storm drainage systems, although other services were not excluded. The stated purpose of the program was to: "motivate the practical and broad use of systems engineering and systems analysis techniques through the use of computer technology in developing new concepts for the total design, development, and management of entire systems of public facilities and services." This paper describes the use of such a computer aided systems technique toward the total design of a regional water supply system.

The Demonstration Project

In one of the first projects in the Systems Engineering Demonstration Program, the City of Cleveland, Ohio and H. U. D. combined to fund a comprehensive regional study to develop a long range expansion program for the water supply and distribution system of the city and adjoining suburban areas. The study will result in a phased program to fulfill the water supply needs of the area over the next four decades to the year 2010.[1] The study combined four major components:

1. Planning — to establish water demand levels through detailed analysis of land use patterns and regional activity patterns using a computer land use model.
2. Engineering — to evaluate the present water supply system, and to formulate several distribution system alternatives in terms of physical and cost feasibility.
3. Systems Analysis — to identify the "most effective" alternative system design using computer-based optimization modeling, and
4. Financial — to evaluate the economic, financial and institutional frameworks pertinent to the proposed future systems.

The entire project was directed toward developing the most flexible and responsive water system design possible, given the great uncertainties of the next forty years. The foundation of this type of design was a demand study which attempted to account for regional development uncertainties in its projections of demand patterns.

Computer modeling and simulation were used extensively to develop possible alternative land use distribution patterns from which inferences for water distribution system design could be made. Future possible public policies and improvements were detailed both to provide greater accuracy in projecting development trends, and to allow the City of Cleveland to plan its water supply system responsively with other regional planning and development efforts. The relationships of water supply and land development were then explored within the systems engineering context of the entire project to develop an efficient system configuration capable of responding flexibly to the probable future needs of the region.

The Planning Method of Developing Demand Estimates

The Planning section of the Cleveland project used the techniques of regional planning to predict future development patterns for actual physical system design. This particular use of planning expertise is unique both to urban planning and water system design. The techniques employed could just have easily been used as the first step in transportation system design, public utility or community facility design on a regional, municipal, or local level. The significance of the technique is not its particular application, but its usage as a preliminary to design work.

The first step in designing or extending a service system is, naturally, to obtain the future demand for that service over time and space. To derive future demand, all the determinants of that demand must be projected into the future. For a water system, the important determinants are:

1. Population size for the study area.
2. Population densities throughout the area.
3. Amount of economic activity (industrial and commercial).
4. Location of economic activity throughout the region.

The planning input forms the first vital step of a comprehensive design system wherein all the parts are integrally connected, all segments of the study combine to systematically analyze the problem, and where solutions can be tested and re-evaluated in a flexible framework. To allow for interaction throughout the design process, the planning data and projections must both be in an easily manipulated form and be comprehensive enough to respond to any reasonable analytic demand made by system designers or researchers. For comprehensiveness the Cleveland Study reverted to the traditional land use planning techniques, and conducted the planning segment as if it were the first stages of preparing a regional plan. By this method, all the necessary inputs for regional land use projections were accounted for, thus greatly expanding traditional service system future demand derivation techniques. By casting a constant eye on water system parameters, the planners could insure the inclusion of all the important water system design criteria within the larger and more dependable framework of regional planning.

After selection of the appropriate study area, standard population and employment projections were made. In addition to these projections, a set of data characteristics (physical, social, transportation, accessibility, community facilities) was established for every point in the region and aggregated by square mile zones. Several examples of these characteristics are mapped in Figure 1. The set of characteristics determined the attractiveness of the zone for various types of development. Future population and employment opportunities in terms of four land uses: heavy employment, light employment, urban development and suburban development, were distributed throughout the region in response to the relative attractiveness of each zone in the region. In effect, the study simulated the region's growth over time by locating all the projected new population and economic activity decade by decade according to the determinants of location from both previous local experience and theoretical input.

To facilitate this simulated growth, to provide a flexible analytic framework, and to allow rapid, accurate and comprehensive manipulation and storage of data, a computerized land use model was employed. The DYLAM II model developed for this study dominates the planning work and is the keystone of the demand projection work. Its major characteristics are that:

1. it allows for the inclusion of multitudinous, diverse data,
2. it can handle problems the size and scale of the Cleveland Study (2, 400 sq. mi.).
3. it can quickly compare the features of any location in the region and match it

with the features desired by particular land uses,
4. it can provide maps of future land use patterns based upon the match-ups of potential locations and land use needs,
5. it can respond to changes or additions to the man-made features of the region and relate such changes to land use pattern changes,
6. it can project over the time periods needed by the study.

The DYLAM II model, which will be explained in the remainder of this paper, produces computer-made maps of the future land use patterns (see Figure 2) which is used for analysis and display. The land use data produced by the program can be used to convert land use patterns into water demand patterns, fulfilling the role demanded of it by the Systems Engineering methodology. Thus, computerized land use models in general, and DYLAM II in particular, can provide the appropriate vehicle for regional service system design.

The Computerized Land Use Model

The model used to simulate the Cleveland region and to project its growth was the DYLAM[2] (Dynamic Land Use Allocation Model) computerized land use model. This model was developed by Brian F. Walsh at the Columbia University Division of Urban Planning. It was revised by the staff of Parsons, Brinckerhoff, Quade & Douglas and the resulting version is DYLAM II.

Subject

The DYLAM model was developed to locate units of physical development in two dimensional spaces according to the relative attractiveness of various sites. In this way, the model approximates the future location decisions of land users — developers, industrialists, governments — based upon the premise that each user has a list of characteristics it desires in a location (or wishes to avoid) and that users select those locations which best satisfy those desires. The model is a matching model which rates all locations in a study area and selects the best location for each type of land use, depending upon that use's locational desires.

For that matter, since the model is based on the universal and fundamental principle of things seeking optimistic placement, the program could conceivably be used for a wide range of problems, not excluding, perhaps, the distribution of canned goods on supermarket shelves, or finding appropriate colleges for a group of prospective students.

Function

The DYLAM model has no internal projection capabilities. Thus, before the model can make future patterns, it must have period by period projections of the new amounts of each land use to be located within the study area throughout the entire study period. Any method may be used to arrive at these increments but the model does not perform this task. Population projections, economic indicators and the like can be used, but the final expression of the future must be in the form of x-number of units of each use for each incremental time period. The basic work of the model is to distribute future increments of development, that is, its function is to allocate the new units of land uses according to a rational pattern or, to a certain degree, to redistribute existing activities if the conditions affecting their original location change appreciably.

The model makes its distribution patterns in discrete time increments, simulating years or, perhaps, decades. Each new time period builds upon the pattern of the previous time period and adds the new projected development, in terms of the number of new lots of each land use. The model produces a land use pattern as its output, reflecting the placement of all development as distributed by the matching procedure outlined above.

Theory

The DYLAM model does not hide behind a sophisticated, obscure and complex theoretical concept. Its basis is very pragmatic — something that has been observed by planners and developers over a long period of time and is generally accepted.

The observation is that land uses have specific needs or priorities of desires in terms of locational factors, and they seek those sites that can best satisfy those relative requirements. Industrial districts, for example, seek flat sites with railroad and highway access, and they are limited in their choices by restrictive zoning, among other things.

As such, DYLAM is behavioral and its core is not any mathematical equation beyond a series of programming statements performing a selective and sequential matching function between site location desires and site characteristics. The land use pattern obtained is not intended to be "optimal". It is supposed to approximate the sum of the multitudinous private and public location decisions made over a given time period which determine the shape of the future of a study area. The location algorithm reflects the rational human location decision process and, to the extent that location dynamics are rational, models that process well. It can even be argued that if the study area and the required amounts of new land are large enough, irrational decisions will balance and the pattern will still be valid.

Method

The basic unit of land is the grid square or lot. A study area is overlayed with a rectangular system of lots, like a checkerboard. This grid system can be of any scale, to include problems from neighborhood planning to regional planning. All data is collected, coded and displayed by grid square. The projected future amounts of land needed to support increases in population and economic activity are also expressed in units of lots or parts of lots. Units of land uses are placed in a grid square like checkers on the checkerboard according to the location algorithm. Lots may be vacant, partially filled, or filled with any of the study's land uses. When it is said that a particular lot has a land use, it means that one "lot-worth" of a particular land use activity has occupied that particular grid square or lot.

The model rank-orders every available lot according to how well it satisfies the needs and desires of a land use type. After scoring each lot and eliminating those having critical conflicts with the needs of a land use, the model then assigns the number of "lots-worth" of the land use needing location to the best available grid squares until all the land required is found. A lot-worth of land use looking for a location may not find an ideal site, but will take the best available site if enough location criteria are satisfied.

One of the basic features of the DYLAM model is the idea that below a certain level of satisfaction with the available lots (the level set by the model's user) a land use simply will not locate, and there will be an incomplete distribution. The assumption is that the land user would rather settle elsewhere if available locations within the study area do not meet its minimum acceptable requirements.

Features

The attributes of any lot are bound to change over time, either through natural forces or planned intervention. Several features of the model account for these changes.

1. There is a lot aging mechanism which accounts for decay of uses over time, and simulates the depreciation of land improvements. This feature is particularly helpful in older areas where redevelopment is the dominant factor of the future.
2. There is a land intensification feature which allows one land use to usurp another, allowing the simulation of increasing urbanization or land use intensification.
3. There is a surrounding lot feature which changes the attributes of a lot depending upon the land uses which locate on its borders. This is useful for simulating nuisance factors, economies of scale and interactions of uses.
4. There is a use clustering factor by which lots already partially occupied with a certain land use become more attractive for further occupation by that use than lots of otherwise equal attraction. This allows simulation of use clustering, in-filling and agglomeration.
5. Most important to the changing of an area's characteristics, however, are the public improvements and policies which determine the attractiveness of a site. For example, if a new highway is built through a grid square, the accessibility of that lot increases, making it more desirable for location. The model accounts for these changes with external public policy inputs through which the user can either: (1) reflect probable changes in the study area's infrastructure, or (2) test the effects of various proposed policies and improvements on the study area's development pattern. In this way, the model becomes a useful planning tool.

Other modifications of the original model were made to produce the second version:

1. Partial lot occupancy was allowed to reflect less than total occupation of a lot by a land use.
2. Dummy or empty lots were allowed to permit any shape for the area.
3. Array capacity was increased to allow:
   2760 lots
   80 lot-wide output maps
   42 lot characteristics
   15 land uses

At the present time, the model is operational, it has been used on several projects and the results appear reliable. A large amount of calibration and testing work was performed with the DYLAM II model before its final projections for Cleveland, which gives credibility to the entire endeavor.

Calibration of the Model

Before the DYLAM model could be used to project land use patterns for the next four decades, all of the parameters within the model had to be set at values which would assure reasonable accuracy in the projections to be made. To obtain this assurance, a calibration exercise was required. When an instrument is calibrated, its measurements are compared to known quantities so that its settings and readings may be made accurate. Such must be done with the outputs of the DYLAM II model. Successful calibration would also improve confidence in the model's adaptibility to a variety of situations.

The simplest and most direct way to perform a calibration was to go back into the past and use the model to project land uses up to the present. Because the present land use pattern is already known, there would be an easy check on the accuracy of the predictions made. This method was deemed appropriate for the model and this particular application.

The goal in this calibration was to take the difference in the extent of land development in 1959 and the present, and to try to locate that amount of land by using the DYLAM model. A check for accuracy would then be made to see whether the land that was projected by the model was the same as the actual resultant land use configuration for 1970. A major assumption made before the calibration exercise could take place was that the dynamics of growth in the past would carry forth into the future over the next four decades. This was an assumption which had to be made before calibrating by using past data and extrapolating to the present time. It was felt that growth in the future would respond to and be influenced by the same factors as in the past, and that any deviations could be taken care of and tested with public policy inputs in future iterations of the model. It took 34 separate runs to obtain satisfactory results and the following is a description of that process.

The land use pattern in 1959 was coded and compared to the land use codes for 1970. Once both periods had consistent coding and the difference between 1970 and 1959 were added up, the calibration exercise could begin by taking the 1959 configuration and trying to add that amount of land development that took place between 1959 and the present.

The overall criterion used for successful calibration was that accuracy be obtained at a reasonable level of lot characteristic matching within the constraint that all of the land needed between '59 and '70 was allocated by the model. The object was to identify the parameters which would satisfy this criterion. For example, if one set of model parameters gave a high degree of accuracy in the placement of land uses but could not locate all of the industrial or residential lots that actually developed over the last ten years, then that set of parameters would have to be adjusted or discarded. The parameters to be set and the variables that could be adjusted were the following:

1. the ordering of the land uses themselves;
2. the use desires of each land use;
3. the NOMAT parameter, which is the maximum number of non-matches allowed between each of the land use desires and the availability of the desired characteristics on the lot for there still to be location of a particular lot;
4. the weighting of lot characteristics. Essentially this variable concerns the mix of lot characteristics, of which this project had 41, which would give the most accurate results. For example, it might have proved desirable to repeat several times a particular characteristic that proved important in terms of the location dynamics of the study area.

The exercise began by accepting the original use desires, lot characteristics matrix and order of land uses, and requiring a 90% match between the desire of a use for a lot and that lot's ability to provide for the land use. It was found that no lots-worth of land could be located and, therefore, the match was reduced down progressively from 75% to 50%, and even further for specific troublesome land uses until practically all the amounts of land that were needed could be allocated. At this point though, the accuracies for all uses except heavy employment were unacceptable. To improve the accuracy of location, an investigation of the constraints on the desires of the land uses was made, especially involving critical needs and critical avoidance. A survey of the actual land uses of the region showed that most land use types had settled for much less favorable locations than was being allowed by the model. Surely, to calibrate the model, actual location habits had to influence the theoretical land use desires originally postulated. With forty-one lot characteristics, too much was required of most lots to be suitable locations, and so the NOMAT level became less important than initially intended.

At the same time, the order of location for the various uses began to be rearranged. Initially heavy industry was placed first, then light industry, urban development and suburban development as in classical location theory and urban economic practice. There were some startling differences in accuracy dependent upon the order of land uses located that had not been foreseen prior to the calibration. For example, if light industry was located last among the four land uses, the accuracy for almost all land uses went up appreciably. In general, heavy industry was the least troublesome land use. It was surmised that this was because heavy industry had particularly good locations and that there was little or no competition for those locations from any of the other land use, so that heavy industry always had a clear road to its preferred site.

Accuracies at the end of 20 or so runs were still below an acceptable level. Some manual investigation into the matter showed that the new units of land located were, in reality, basically in-filling previously occupied lots of the same land use type. That discovery led to the development of a new model parameter, i. e. the discount. The discount would be a reduction in the number of characteristics that did not match when a particular use looks for a particular location due to the fact that the lot was previously partially occupied with that particular land use. A discount of two "bonus" matches for lots containing some of the land use seeking locations was set, and it was noted that the accuracy for heavy industry jumped to 100%, the accuracy for light industry jumped to 84%, the accuracy for urban development jumped from a level of 35 to 45% and that suburban development lost accuracy from about 67% to about 57%. The decrease in accuracy for suburbs indicated that in-filling was not the case with that land use, causing temporary discomfort with using a discount. It seemed, however, that the discount was on the right track, having raised accuracies considerably. And so the discount was increased to three, i. e. three was subtracted from a lot's number of non-matching characteristics for a land use if that land use had already occupied part of that lot. The accuracies then jumped into acceptable ranges across the board, which are the final accuracies as presented in Table 1.

TABLE 1 – ACCURACY

(i. e. % of lots located by DYLAM that correspond to actual lot locations)

Heavy Employment	100%
Light Employment	87%
Urban Development	60%
Suburban Development	84%

It was also found that a discount level of three, it made no difference at all in what order the land uses locate, reflecting the fact that most land uses developed on lots that previously contained some development of that same type, so there was in fact not very much competition for lots at all. Each land use type seemed to have its own peculiar needs for sites that were mutually exclusive to other land uses. In-filling was the most important phenomena in this region. The most remarkable result of the calibration exercise was that given the discount of three, the ordering of land uses was not important at all. This runs directly contrary to traditional location theory and raises questions about the nature of Cleveland. Further research on this topic would definitely be in order.

The entire calibration exercise was valuable not only for the setting of parameters, but for the information it yielded about the dynamics of the study region and the growing confidence in the model it engendered. It is significant to develop a land use model which has the ability to be tested for accuracy as well as just being unconditionally operated within the confines of a single study. The result is a potentially powerful tool in the development of computer-aided techniques to investigate and possibly alleviate urban problems.

Potential Applications of the DYLAM II Model

Needless to say, however, DYLAM II is a model which is still in its early stages of development, and one that could benefit from further applications, experimentation and elaboration. As is the case with most models, there is room for growth and evolution. The results up to now support the contention stated and implied in this paper that DYLAM II can be considered for listing in the inventory of operational urban land use models.

The model can be a major tool in the development of a master plan, because it utilizes all of the requisite techniques, imposes the same discipline, and allows for the experimentation with potential programs and policies. The ability for public program testing makes it particularly useful in master planning. The same could be said for community facility system planning and, as has been demonstrated in the Cleveland Project, public utility system planning and design.

Additionally, the model's ability to provide before and after pictures of a region differing only by the implementation of specific public policies makes it extremely helpful for impact studies of highway design, mass transit system design, airport location studies and transportation system corridor studies.

It can be said that the limitations upon the applicability of the DYLAM II model will only be discovered through further attempts to apply the model. Its flexibility and universality make *a priori* judgments as to its potential applications empty exercises. Further applications might include the testing of alternative tax structures, investigations of social pathologies, effects of government reorganizations, site planning and many, many more. Uses for this type of "search and match" are limited only by the imagination of its users.

Acknowledgments

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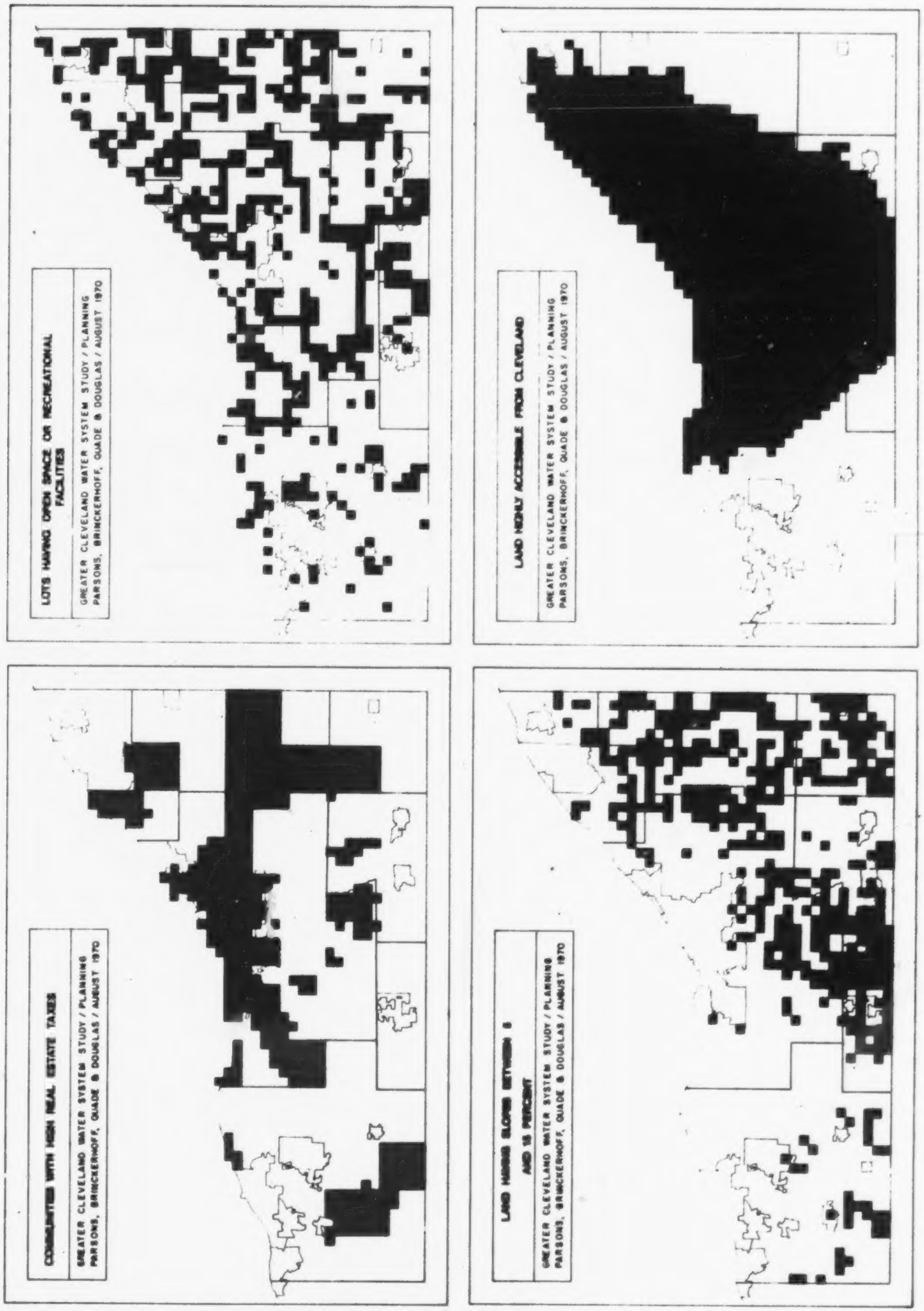
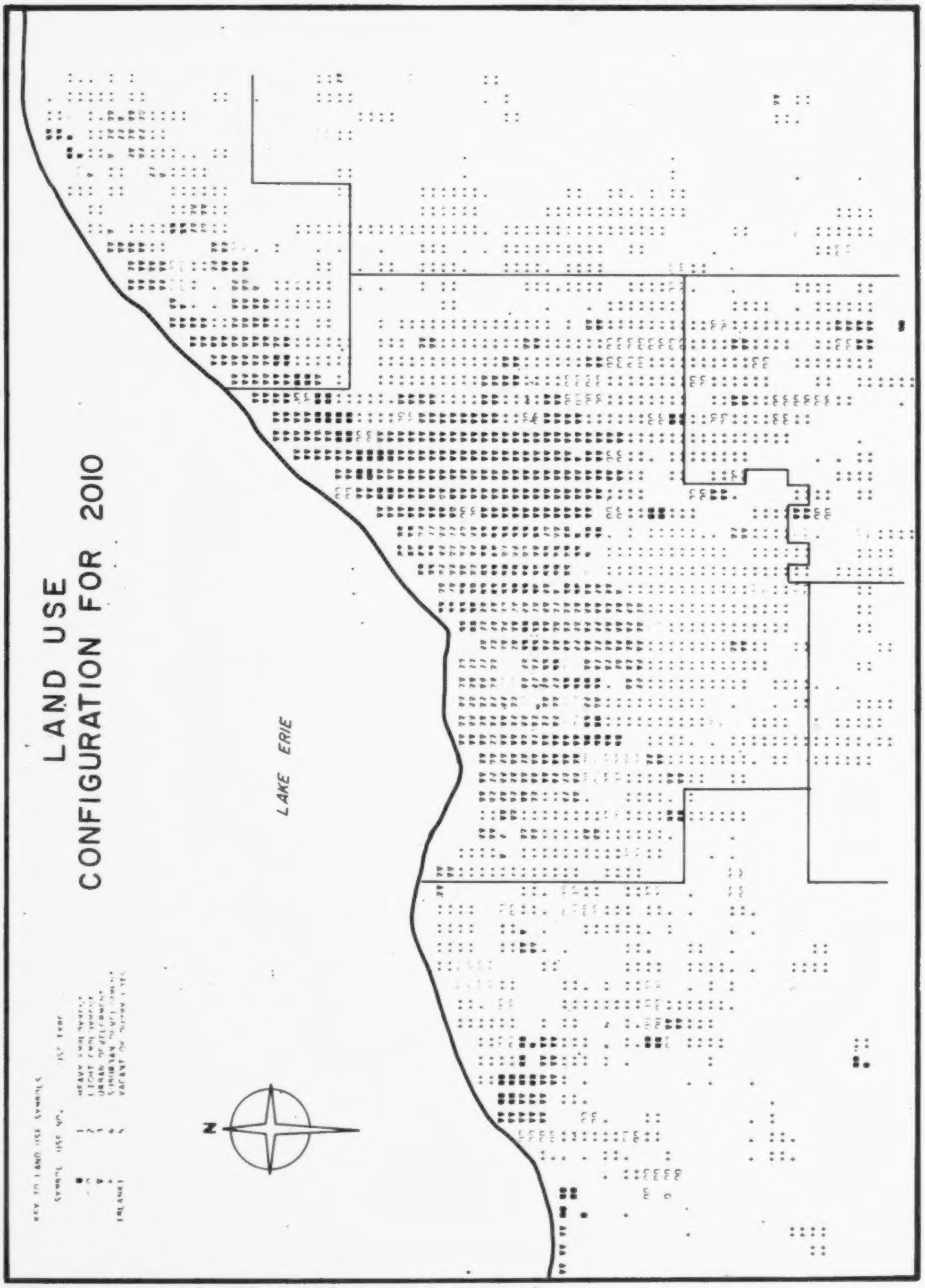

LOTS HAVING OPEN SPACE OR RECREATIONAL FACILITIES
GREATER CLEVELAND WATER SYSTEM STUDY / PLANNING
PARSONS, BRINCKERHOFF, QUADE & DOUGLAS / AUGUST 1970
LAND HIGHLY ACCESSIBLE FROM CLEVELAND
GREATER CLEVELAND WATER SYSTEM STUDY / PLANNING
PARSONS, BRINCKERHOFF, QUADE & DOUGLAS / AUGUST 1970
COMMUNITIES WITH HIGH REAL ESTATE TAXES
GREATER CLEVELAND WATER SYSTEM STUDY / PLANNING
PARSONS, BRINCKERHOFF, QUADE & DOUGLAS / AUGUST 1970
LAND HAVING SLOPES BETWEEN 6 AND 15 PERCENT
GREATER CLEVELAND WATER SYSTEM STUDY / PLANNING
PARSONS, BRINCKERHOFF, QUADE & DOUGLAS / AUGUST 1970

Figure 1

CLEVELAND WATER SYSTEM STUDY


LAND USE
CONFIGURATION FOR 2010
LAKE ERIE
N
KEY TO LAND USE SYMBOLS
SYMBOL USE NO. USE TYPE
1 HEAVY INDUSTRY
2 LIGHT INDUSTRY
3 URBAN DEVELOPMENT
4 SUBURBAN DEVELOPMENT
5 VACANT OR RURAL LAND

PARSONS, BRINCKERHOFF, QUADE & DOUGLAS

Figure 2

21-3-9

INCREASING THE UTILITY OF URBAN AND REGIONAL MODELS: A TECHNIQUE FOR THE EVALUATION OF THE UTILITY OF A MODEL OF A MAJOR URBAN/REGIONAL SUBSYSTEM

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Introduction

Over the past decade, urban model builders have become increasingly concerned with the validity of their models. There seems to have been somewhat less concern about the utility of urban models. One of the main purposes of this paper is to stimulate a more thorough examination of the utility of present and, especially, future urban models. The outlines of a technique to be used in the evaluation of the utility of an urban model are presented below.

The distinction made between validity and utility is important. A model is a representation of a sub-set of reality. If the model has validity, it is an accurate representation (in some relevant respect) of that sub-set of reality. If the model has utility, it answers questions of interest to the model's users. These two terms should not be confused. It is possible to construct a model which has validity but no utility; likewise, a model can have utility but no validity.

The goal of a model builder should be to build a model which has both validity and utility. If the goal is a useful and valid model, there are two possible sequences for constructing such a model. The first is to construct a model that is valid, and once satisfied with its validity, test its utility, and modify it as necessary to make it sufficiently useful. The second possible sequence is to construct a model that is useful, and once satisfied with its utility, test its validity, and modify it as necessary to make it sufficiently valid. The second approach is a more efficient way to achieve the goal.

The utility evaluation technique which I describe below is applicable, I believe, to a wide variety of model-building situations. However, I am most interested in its application in the evaluation of urban models. In particular, I am concerned with models to be used by public policy makers. Thus the basic question posed in this paper is: how can a model of a major urban and/or regional subsystem (e.g., housing, health, education or transportation) be developed to maximize its utility for public policy makers?

Evaluation of Model Utility

The evaluation technique I propose is remarkably simple. The following four questions are to be answered for the model which is to be evaluated.

1) Who are the potential users of the model?

2) What consequences are considered by the model's potential users when evaluating actions intended (primarily) to affect the sybsystem (i.e., the major urban and/or regional sybsystem represented by the model)?

3) What actions intended (primarily) to affect the subsystem are open to the model's potential users?

4) To what extent can the model aid the user in evaluating the actions (identified in question 2) in terms of the consequences (identified in question 3)? Or, in other words, what is the utility of the model?

To clarify the use of this technique an example will be presented. The model to be evaluated in the example is the New York State Regional Housing (NYSRH) model, which represents a regional housing system. As the main intent of this paper is to present a technique for the evaluation of model utility, the details of the NYSRH model will be referred to only where absolutely necessary. (1)

Potential Users of the Model

It is intended that the NYSRH model will be useful to a wide variety of public decision makers; although the model might be useful for certain private decision makers, this is unintentional. More specifically, the model is intended for use by public policy makers within the United States; while the model might be of use outside the U.S., it is not aimed at these users. The NYSRH model is intended to be useful to decision makers in both the executive and legislative branches of government; the model might be useful, in certain cases, to decision makers in the judicial branch, but this is an unintended, though not undesirable, use.

It is intended that the NYSRH model will be useful to many public decision makers at several governmental levels: the federal, state, regional and local levels. Specifically, the model's users might include congressmen, senators, state legislators, city councilmen, the President, governors, mayors, and numerous non-elected officials in HUD, state, regional and local planning, renewal and housing agencies. This list is not meant to be all-encompassing, but it does include a sizeable proportion of the model's potential users.

Consequences Considered by the Potential Users

What are the general characteristics of the objectives of the model's potential users? This is a somewhat difficult question to answer, even for a single user, as objectives are usually not explicitly stated. And it is possible, indeed likely, that these objectives will change over time.

When speaking of "objectives" here, I really mean to imply something like "housing objectives" or "objectives related to housing". But, as the housing system is an open system, rather than a closed one, it is difficult to be precise about exactly which objectives are included in, and which are excluded from "objectives related to housing". Almost all objectives of any public decision maker might be related to housing, either directly or indirectly. For instance, the objective to "minimize water pollution" may imply the necessity of prohibiting construction (including housing) on certain types of soil; thus, the objective is related to housing. In fact, to be more exact, I am really interested in determining the consequences which are considered in making decisions regarding housing, rather than determining the objectives of the decision makers. (Of course, the consequences considered and the objectives are closely related.)

A more precise statement of the question I am posing is: what are the general characteristics of the consequences considered by the model's potential users when evaluating government actions intended (primarily) to affect housing?

This re-phrased question has (purposely) excluded two possibilities contained in question as originally stated in the opening sentence of this section. The first of the two excluded possibilities is a government action which is not intended primarily to affect housing (this is a type B action: see Figure 1.). For example, the decision to close down a large military installation may have a fairly significant impact on the housing situation in the area, but if the action is taken primarily because of its non-housing effect (e.g., its effect on the Department of Defense budget), then this action is not "a government action intended (primarily) to affect housing".

The second possibility which is excluded is a consequence which is affected by a government action intended (primarily) to affect housing, but which is not considered in evaluating the action. For instance, an objective of some decision makers might be "to improve the delivery of health services to residents" of an area. The location of new housing with respect to the location of existing health services might very well have an impact on the achievement or non-achievement of the objective. Nevertheless, if, in choosing among alternative locations of new housing, the impact of each location upon the achievement of the objective "to improve the delivery of health services" is not considered, then this consequence is not, obviously, one which is considered "when evaluating government actions intended (primarily) to affect housing". In this exam-

Possible government actions:	Consequences of action which are considered:	Consequences of action which are not considered:
Type A Action: Government action intended (primarily) to affect the housing system	Type 1 Consequence: Consequence for the housing system	Type 3 Consequence: Consequence for the housing system
	Type 2 Consequence: Consequence for some non-housing system	Type 4 Consequence: Consequence for some non-housing system
Type B Action: Government action intended (primarily) to affect some non-housing system	Type 1 Consequence: Consequence for the housing system	Type 3 Consequence: Consequence for the housing system
	Type 2 Consequence: Consequence for some non-housing system	Type 4 Consequence: Consequence for some non-housing system

Figure 1. Possible government actions and consequences considered and not considered.

ple, we have a type 4 consequence (an unconsidered consequence for some non-housing system: in this case, the health system) of a type A action (see Figure 1).

To repeat, the question to be answered in this section is: what are the general characteristics of the consequences considered (type 1 and type 2 consequences) by the model's potential users when evaluating government actions intended (primarily) to affect housing (type A actions)?

The tentative answer to this question will be, not surprisingly, divided into two parts: a) the general characteristics of the type 1 consequences, and b) the general characteristics of the type 2 consequences.

The use of the phrase "the general characteristics of the consequences considered" is intentional. A brief digression will explain the use and meaning of this phrase.

In order to make a choice between two or more alternatives, a decision making body (or, even a single decision maker) must have, among other requirements, a set of objectives. This set may be explicit, or, more likely, implicit, but its existence is necessary if a choice is to be made.

Most, if not all, recently developed urban and regional models are descriptive; a descriptive model "merely" presents a set of information (both clues and guesses) about a (past, present and/or future) sub-set of reality. A descriptive model is objective-free, in the sense that it requires that a set of objectives be brought to it, if the information provided by the model is to be used in making decisions. Stated in another way, the information provided by a particular model might be used by decision maker A, with a set of objectives O_a, to choose action 1 rather than action 2; the same information might be used by decision maker B, with a different set of objectives, O_b, to choose action 2 rather than action 1. Thus, a single model need not be neatly tailored to fit the objectives of a specific user.

On the other hand, a model, such as the

NYSRH model, which is being designed to meet (at least some of) the information needs of a broad spectrum of public decision makers, must consider the general characteristics of the objectives of these (potential) model users. For example, it is (theoretically, at least) possible that some decision making bodies might have a set of housing objectives which included the color of the housing unit as a relevant characteristic (e.g., an objective of some decision makers might be "to maximize the number of red houses" in a given area, while the objective of other decision makers might be "to maximize the variety (in terms of color) of housing units" in a given area). If, in fact, "color of housing unit" was an important characteristic, in terms of the objectives of a significant proportion of the model's potential users, then, the model should provide the desired information. In contrast, if, as seems to be the case, few, if any, potential users consider the color of housing units as a major factor in making decisions about housing, then the housing model can safely ignore "color of housing unit".

Now I turn to the basic question posed at this stage of the model evaluation process: what are the general characteristics of the consequences considered by the model's potential users when evaluating government actions intended (primarily) to affect housing?

There are several consequences for the housing system which are considered by (at least) some public policy makers when evaluating government actions intended (primarily) to affect housing. I will briefly describe those that seem, to me, likely to be most important to government decision makers in the 1970s.

1) First, there is the question of quantity. What will be the impact of the action on the total number of housing units within a specified geographic area (e.g., within the nation, within a metropolitan region, within a city)?

2) Next, there is the question of the quantity (effectively) available to various population sub-groups within a specified geographic area. For instance, what will be the impact of the action on the number of housing units effectively available to blacks living in the U.S.? Or, what will be the impact of the action on the number of housing units effectively available to low-income households in the Los Angeles metropolitan region? Or, what will be the impact of the action on the number of housing units effectively available to the elderly living in Newark? When asking questions of this sort, the population sub-groups of interest will probably be identified in terms of racial, income and/or age characteristics.

3) Third, there is the question of the distribution of housing units and population. For example, what will be the impact of the action on the distribution of multi-family units among the cities and towns of the Atlanta metropolitan region? Or, what will be the impact of the action on the distribution of the black population among the political jurisdictions in the St. Louis metropolitan region? Or, what will be the impact of the action on the distribution of low-income households among the census tracts of the Grand Rapids metropolitan region? In most cases, interest is likely to center upon the distribution of households rather than the distribution of housing units (although these are, of course, closely related). And interest, even at the federal level, will be focused upon the distribution of households among the geographic and/or political subdivisions of regions. The household characteristics most often considered will include income, race and age.

4) Finally, there is the question of the quality of housing units. Decision makers will be interested not only in the quantity of housing available, but in the quality of these units as well. For instance, what will be the impact of the action on the number of housing units of acceptable quality in the nation? Or, what will be the impact of the action on the number of acceptable quality housing units effectively available to blacks in the Tulsa metropolitan region? Or, what will be the impact of the action on the distribution of acceptable quality housing units among the political subdivisions of the Hartford metropolitan region?

Now we turn from type 1 to type 2 consequences. Again, I will describe those consequences that seem, to me, likely to be most important to government decision makers in the 1970s.

5) First, most obvious, and most important in many, if not all, cases, there is the question of cost to the government. How much will it cost the federal government, for instance, to implement a rent subsidy program so that every American household can reside in a housing unit of acceptable quality? Or, how

much will it cost the state of Kentucky to build 100,000 public housing units? Or, how much will it cost New York City (in lost taxes) to change its property tax structure so that it is no longer necessary for landlords to let existing housing units deteriorate?

6) Second, there is the question of impact on the physical environment. For example, what would be the impact on the environment of a federal program to locate 25 new towns in the Rocky Mountains? Or, what would be the impact on water pollution of the construction of high density housing units on a floating platform in San Francisco Bay?

7) Next, there is the question of transportation, and, particularly, journey-to-work. If the federal government, for example, was to encourage, through a rent subsidy program, the migration of low-income households from the central city to the suburbs, what would be the impact on metropolitan transportation?

8) Next, there is the question of existing social bonds. For instance, if several blocks of deteriorating but occupied housing in New York's Chinatown were to be demolished, what would be the impact of this action on existing social bonds among residents of the neighborhood?

9) Finally, there is the question of employment. If the federal government constructs 1,000,000 units of public housing, what will be the impact on employment? Or, if a program to rehabilitate all housing units of unacceptable quality in San Antonio is implemented, what will be the impact of this action on employment?

In summary, nine major categories of consequences have been identified. Each of these nine categories, as indicated in the examples given, includes a large number of specific consequences that might be considered. Given the heterogeneity of the potential users of the NYSRH model, it is obviously impossible to identify all the major categories of consequences that are likely to be considered by all potential users. However, I believe that this list includes the consequences that are most likely to be considered by government decision makers in the 1970s in evaluating government actions intended (primarily) to affect housing.

Actions Open to the Potential Users

The number of government actions which might be taken with the (primary) intention of affecting housing is extremely large. It is, therefore, impossible to list any sizeable proportion of the possibilities. Nevertheless, ten major categories of actions have been identified. It is intended that this set of ten categories will be substantially (though probably not completely) both mutually exclusive and exhaustive.

1) The government can build housing units. Prior to construction, certain characteristics of these units must be specified (e.g., location, value and type of structure). In addition, certain characteristics of the residents of these units might be determined (e.g., owner v. renter, income, age, race). Among the possibilities that exist within this category, very few have actually been tried. Government construction of housing to date has been largely confined to low-value, high-rise structures located in central cities, and available only to low-income renters. Many other actions involving government construction are (theoretically) possible.

2) The government can demolish housing units.

3) The government can convert housing units into non-housing structures. Here, too, there are numerous possibilities, in terms of the location, value, quality and structure of the housing units to be demolished or converted. And certain characteristics (e.g., income) of the residents of these units might be designated.

4) The government can convert non-housing structures into housing units. Again, there are many possibilities within this category.

None of the preceding three actions has been undertaken in any major way to date, with the exception of the demolition that usually accompanies urban renewal.

5) The government can change the quality of existing housing units. Certain characteristics of the units to be affected must be specified, prior to the government action: for instance, the location, quality, value and structure. Government rehabilitation of housing units of unacceptable quality is an example of this kind of action.

6) The government can impose constraints on potential builders and present owners of hous-

ing units. These might be constraints on the total number of units to be built, or, more likely, the number of units with certain characteristics might be limited. Such constraints include zoning, subdivision regulations and building codes, which often place severe constraints on the housing that may be built, in terms of location, value, structure and/or quality. Government regulations prohibiting the builder or owner, when selling or renting, from discriminating on the grounds of race is another example of a constraint.

7) The government can subsidize builders. Only certain types of housing units might be eligible for these subsidies; these types could be indicated by location, value and/or structure. The subsidies might, for example, take the form of low interest rate loans, reduction in taxes, or government provision of land or utilities at low cost.

8) The government can subsidize non-resident owners. Certain characteristics of the owners (e.g., age) to be subsidized, or characteristics of the housing units owned (e.g., location, value) might be denoted. Subsidies might take the form of reduction in taxes or low interest rate loans.

9) The government can subsidize households. These subsidies might be limited to only certain households; the eligible households could be defined by tenure (renter v. owner), income, age and/or race. In addition, subsidies may be available only to households residing in certain types of housing units; the location, value, structure and/or quality of the housing could be specified. Rent subsidies and low interest rate loans to resident home owners are both subsidies of this type.

10) Finally, the government can sponsor research intended to affect the housing system. The government-supported attempt to lower the cost of housing through industrialized housing is an example of such research.

While the ten major categories of actions just listed may seem rather insubstantial, in fact, a huge number of alternative government actions is included. Why? First, each category contains many different actions. Consider, for instance, the subsidization of households (category 9). One possible action is a government provision of a rent subsidy to low-income renters living in housing units in central cities. Another possible action is the subsidization (in the form of property tax benefits) to elderly homeowners. Hundreds, even thousands, of other specific actions could be considered within this category.

Second, any specific action can be carried out at many different levels of financial support. For example, an action to construct low-value, high-rise housing units for low-income households in downtown Detroit could be carried out at a support level of $1 million or $100 million. The shift in expenditures produces quite a different action.

It is important to point out that, in addition, a total government housing policy might involve not just a single action, but a combination of actions. And, obviously, within any given set of actions, the emphasis can vary. For instance, a total government housing policy might include both a household subsidy action and a builder subsidy action. But the policy could emphasize the household subsidy, or the builder subsidy, or neither

In sum, there are a vast number of alternative government actions which might be taken with the (primary) intention of affecting housing. In choosing among alternatives, the government decision maker will want to evaluate each action in terms of one or more of the consequences identified in the preceding section. How can the NYSRH model aid the decision maker in this task of evaluation? It is to this question that I turn next.

Utility of the Model

It would have been convenient if I had identified, in the preceding two sections, a) a mutually exclusive and exhaustive set of, say, 25 specific consequences which are likely to be considered by some public decision makers when evaluating government actions intended (primarily) to affect housing, and b) a mutually exclusive and exhaustive set of, say, 100 specific government actions which might be taken with the (primary) intention of affecting housing. If this were the case, then, in this section, I could "merely" answer 2500 (100 actions x 25 consequences of each) questions of the following form: can the NYSRH model aid the decision maker in evaluating the ______ consequences of the ______ action? Although this exercise would be extremely time-consuming, it would have the advantage of specifying in great detail the utility of the NYSRH model.

But, what I have done is to identify nine major categories of consequences, and ten major categories of actions. Given this starting point, the most reasonable approach seems to be: first, to ask (for each of nine categories) if the NYSRH model can aid the decision maker in determining consequences within the category, and, then, to ask (for each of ten categories) if the model can aid the decision maker in evaluating actions within the category. When these nineteen questions are answered, we will then have an answer (though, admittedly, still somewhat vague) to the central question of this section: how can the NYSRH model aid the public decision maker in choosing among alternative actions intended (primarily) to affect housing?

For convenience, the consequences and actions will be discussed here in the same order as they were above. The nine categories of consequences are discussed first.

1) Can the NYSRH model aid the decision maker in determining the total number of housing units within a specified geographic area? The answer is: it depends upon the size of the area. The NYSRH model can aid in determining the number of housing units in a (housing market) region, or in an area larger than a region (e.g., a state, or the nation). The model cannot aid in determining the number of units in an area smaller than a region (e.g., a city, a neighborhood, a block). Thus, for example, the NYSRH model can aid in determining the total number of housing units in the Nashville region in 1985, but it can't aid in determining the number of housing units in downtown Nashville in 1985.

2) Can the NYSRH model aid the decision maker in determining the quality of housing units (effectively) available to various population sub-groups? In one sense, the answer to this question is an unequivocal no. This answer is a result of the model's often unrealistic assumption that housing supply reacts quickly and completely to demand. Ignoring, for the moment, the problems created by this assumption, the answer to the question becomes: it depends on the population subgroups. The model can aid in determining the quantity of housing units (effectively) available to population sub-groups defined by income and/or age characteristics, but can't aid when population sub-groups are defined by other characteristics, such as race. Therefore, while the model can help determine the quantity of housing units (effectively) available to the low-income elderly in the Wichita region in 1990, it can't provide information on the number of units (effectively) available to low-income blacks in the Wichita region in 1990.

3) Can the NYSRH model aid the decision maker in determining the intra-regional distribution of housing units and households? No, the model distributes neither housing nor households geographically within the region.

4) Can the NYSRH model aid the decision maker in determining the quality of housing units? Since the model does provide information on the value of housing units, to the extent that quality is related to value, the model can aid in determining the quality of housing units. Thus, the model can, for instance, determine the number of low value units in the Mobile region in 1980. But, not all low value units are necessarily of unacceptable quality, and not all units of unacceptable quality are necessarily low value; however, some impression about quality can be gained by examining the model's information on the value of housing units.

5)-9) Can the NYSRH model aid the decision maker in determining: 5) the cost, 6) the impact on the physical environment, 7) the impact on transportation, 8) the impact on existing social bonds, or 9) the impact on employment? No, the model can't aid in determining any of these.

Next, the ten categories of government actions are discussed.

1) Can the NYSRH model aid the decision maker in evaluating government construction of housing units? Yes, if only the value, tenure and type of structure are specified. If other characteristics of the housing units (e.g., location) are designated, and/or if characteristics of the households to reside in these units (e.g., income, age, race) are indicated, the model can't handle these additional specifications. The model can, for example, aid in evaluating the consequences of government construction, in 1978, of 10,000 low-value, renter-occupied, multi-family housing units in the Seattle region. However, the model cannot

aid in evaluating the consequences of government construction, in 1978, of 2,000 housing units for the elderly in the Syracuse region.

2) Can the NYSRH model aid the decision maker in evaluating government demolition of housing units? Yes, but only to the extent that the overall demolition rate for housing units of each type (denoted by value, tenure and structure) can be varied (this rate reflects both the units demolished by the government and those demolished by other forces). It is not possible to demolish a precise number of housing units of a particular type, although with the careful selection of the rate, this number can be approximated. Even within this rate limitation, the model cannot handle specifications of the location of housing units to be demolished, nor can the characteristics of residents (e.g., income, race) of the units be designated. For example, the model can aid in evaluating the consequences of government demolition, in 1974, of 5,000 units of medium-value, owner-occupied, single-family housing units in the Los Angeles region. But, the model can't aid in evaluating the consequences of government demolition, in 1974, of 5,000 units in Pasadena, because location can't be indicated.

3) Can the NYSRH model aid the decision maker in evaluating government conversion of housing units into non-housing units? Conversion is included in the demolition rate, and thus, cannot be separated from demolition. Therefore, the model can aid in evaluation of conversion as well as it can aid in evaluation of demolition (see paragraph 2, immediately above).

4) Can the NYSRH model aid the decision maker in evaluating government conversion of non-housing structures into housing units? Conversion into housing units is included in construction, and can't be separated from construction. The model can aid in the evaluation of conversion into housing as well as it can aid in the evaluation of government construction (see paragraph 1, three paragraphs above).

5) Can the NYSRH model aid the decision maker in evaluating government action to change the quality of existing housing units? As mentioned above, in discussing the model's ability to aid in determining the quality of housing units, the model provides information on value, but not on quality. Therefore, the model can't aid in evaluating government action to change the quality of existing units, unless these changes in quality can be expressed as changes in value.

6) Can the NYSRH model aid the decision maker in evaluating government-imposed constraints on potential builders and present owners of housing units? The answer is no: the model cannot handle the imposition of constraints such as zoning, building codes, and anti-discrimination laws.

7) Can the NYSRH model aid the decision maker in evaluating government subsidies to builders? No. Given the model's equilibrium (supply will meet demand) assumption, there is no way (including subsidies to builders) the government can, in terms of the model, affect the total supply of non-government-built housing.

8) Can the NYSRH model aid the decision maker in evaluating government subsidies to non-resident owners? These subsidies can be handled indirectly by the model: the probabilities that existing housing units will change to different categories can be changed to represent the policy. For instance, a subsidy to non-resident owners of all low-value, renter-occupied, multi-family units in the Denver region could be handled by a decrease in the demolition rate for this type of housing unit. So, the model can indirectly, but not directly, aid in evaluating subsidies to non-resident owners, as long as the subsidies are indicated only in terms of the value, tenure and/or structure of the units whose owners are to be subsidized.

9) Can the NYSRH model aid the decision maker in evaluating government subsidies to households? Yes. Again, these subsidies can be handled indirectly. The probabilities that existing households will change to different income categories can be modified to represent the action. A government subsidy to some (or all) low-income elderly households in the Minneapolis-St. Paul region, for instance, can be handled by the model. But, intra-regional location can't be designated; only the income and age of the households to receive the subsidy can be specified.

10) Can the NYSRH model aid the decision maker in evaluating government-sponsored research? It cannot do so directly. If the results of the research can be delineated, then, in some cases, the model could aid in

Major categories of consequences considered:

Major categories of government actions:	1	2	3	4	5	6	7	8	9
1	X	X		X					
2	X	X		X					
3	X	X		X					
4	X	X		X					
5									
6									
7									
8	X	X		X					
9	X	X		X					
10	X	X		X					

Note: X indicates the NYSRH model can aid the government decision maker to some extent (i.e., maybe, partially and/or in some specific cases) within the general case. (See accompanying text for detailed explanation.) A blank indicates the NYSRH model cannot aid the government decision maker within the general case.

Figure 2. Utility of the NYSRH model for the government decision maker.

evaluating the impact of the results. The model's ability to help will vary greatly, depending on the research to be evaluated.

Nineteen questions have been asked and briefly answered in this section in an attempt to determine the utility of the NYSRH model. Figure 2 presents a summary of this section. As should be readily apparent, this section has not been written as a glowing advertisement for the NYSRH model. Figure 2 indicates very clearly the model's limitations. Of 90 possible cases in which a government decision maker might desire aid from a housing model, the NYSRH model fairly clearly can not help in 69 cases. In the other 21 cases, the NYSRH model can provide some aid. In none of the 90 cases, however, can the NYSRH model aid in answering every specific question that falls within the case.

On the other hand, it is important to keep in mind that there are a large number of specific questions that the model can aid in answering. For example, consider the case where action 1 (row 1 in Figure 2) intersects consequence 1 (column 1). The general question asked in this case is: can the NYSRH model aid the decision maker in evaluating the consequences, in terms of the total number of housing units within a particular geographic area, of government construction of housing? The answer to this general question, as indicated in Figure 2, is: maybe, partially, and/or in some cases. But, there are many specific questions which fall within the general question; and the answer to many of these is: yes. For example: can the NYSRH model aid the decision maker in determining the total number of housing units that will exist in the Toledo region in 1980 if the government constructs 10,000 units of low-value, renter-occupied, multi-family housing during the 1975-80 period? The answer to this specific question is: yes.

In sum, the evaluation of the utility of the NYSRH model for public policy makers indicates that the model is of limited utility. It can aid in many specific decision making situations, but there are many situations in which the model has little or no utility.

Conclusions

The evaluation of the utility of the NYSRH model has been presented in detail not to demonstrate anything in particular about the model, but rather to illustrate the use of the evaluation technique. It is my contention that this technique could prove useful for the evaluation of any model of a major urban and/or regional subsystem. In fact, the technique is so simple and straightforward that it is likely that it has been used implicitly in the evaluation of some models. I propose that, in the future, the technique should be used explicitly.

It is most worthwhile to use this technique to evaluate the probable utility of a proposed model prior to its construction. Use of the technique preceeding the construction of the model would permit, even encourage, changes in the proposed model to increase its utility. However, it is also worthwhile to use this technique to evaluate models already constructed. Two or more models of the same urban subsystem can be compared in terms of utility. Or, a single model can be evaluated prior to its modification, so that its utility can be substantially increased through modification (this, incidentally, was the reason for the evaluation of the NYSRH model).

Public policy makers need urban models which have both validity and utility. But while the evaluation of urban models in terms of certain explicit validity criteria is becoming fairly commonplace, explicit utility tests are non-existent. It is foolish, I believe, to allocate resources to validate a non-useful model. Thus, I propose that all urban models be subjected to some sort of utility test prior to validation. The utility evaluation technique described in this paper is hardly the required test, but at least it can be viewed as a step in the right direction. The challenge is to develop much better utility tests so that increasingly more useful urban models can be constructed.

Notes

1. The NYSRH model is described in my article, "The New York State Regional Housing Model: Simulation for Public Policy-Making", Simulation and Games, v. 2, no. 2 (June 1971), pp. 131-148.

22: MAN-MACHINE SYSTEMS

HUNCH
AN EXPERIMENT IN SKETCH RECOGNITION

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James Taggart

This paper highlights the operations and problems of a set of computer programs called HUNCH. The specific goal of HUNCH is to be able to recognize and make inferences about a user's sloppy, incomplete and equivocal drawings without that user having to be more explicit or categorical than he would be with an onlooking human colleague. Steps toward this goal are being made within a particular context -- architecture -- that furnishes a "knowledge base" or "assumption base" from which programs can procure (rather than develop) those heuristics necessary to handle two dimensional and three dimensional ambiguities.

While HUNCH is indeed an exercize in "computer graphics", we believe that a great many of its operating principles are characteristic of all kinds of future systems that will be expected to cope with vague information and to deal with nebulous ideas. For example, 1) we not only expect the program to make errors, but also to benefit from errors (ie: to improve its recognition ability and context handling ability); 2) we expect the program to support an evergrowing acquaintence with the user (ie: a knowledge of his ideosyncracies, habits, whims); 3) we anticipate that the program will have many channels of access to the real world (to the extent of recognizing gestures and smiles); 4) we insist that the program puruse a multiplicity of candidate "solutions", sorted and selected by "criticizer" programs.

Since 1967, the authors[1] have argued that computer-aided design is an issue of artificial intelligence, that machines have to understand the meaning of decisions in order to be partners in making them. We have advocated the exploration of artificial intelligence and have condemned computerized solution generation which does not consider it. One severe consequence of this position is that there remains very little to work on both because of the state of the art of computer sciences in general, and because intelligence per se cannot be tackled in parts.

Sketch recognition has provided us an interim domain. While it is certainly difficult to shift between wanting to deal with "partially formed ideas" and wanting a program to find corners (which is what most this paper is about), it is a topic that has inherent uncertainties and ambiguities at all levels. It is representative of a class of problems that can be tackled with modesty, but in the ultimate case, require an intelligence.

Acknowledgements

Precursory work commenced in 1966 in a project called URBAN5 jointly sponsored by IBM and MIT. Actual work, however, started only in early 1970 with the Bachelor of Architecture thesis of Mr. James Taggart. This work was conducted within the Architecture Machine Group at MIT and was supported by the Ford Foundation. The more concentrated effort began in the summer of 1970 with a grant from the Graham Foundation for Advanced Study in the Fine Arts and major support from MIT's Project MAC (Advanced Research Projects Administration contract N0014-70-A-001).

At present HUNCH is being developed as an integrated package to act as a front end for any system for "Computer Aids to Participatory Architecture",[2] sponsored by the National Science Foundation.

Along with these many generous sponsors, the authors would like to thank Dr. Gordon Pask who, in spring 1971, provided radical inputs, which guided the project into new directions.

Introduction

We view the problem of sketch recognition as the step by step resolution of the mismatch between the user's intentions (of which he himself may not be aware) and his graphical articulations. In a design context, the convergence to a match between the meaning and the graphical statement of that meaning is complicated by continually changing intentions that result from the user's viewing his own graphic statements. In some sense, the sketch acts as a form of memory for the user while he loops, so to speak, into the real (physical) world to gain a better understanding of his problem. Consequently, the nature of his drawing (ie:the wobbliness of the lines, the collections of overtracings, the darkness of the lines) has important meanings for the most part overlooked in computer graphics. We have already proposed that: "A straight line 'sketch' on a cathode ray tube could trigger an aura of completeness injurious to the designer as well as antagonistic to the design."[3]

HUNCH tries to take into account some usually overlooked (or not taken seriously) graphic subtlties such as: speed of drawing, pressure upon the pen, and crookedness of lines. At present, this is for the purpose of making those transformations necessary to pass from a drawing that is meaningful to the user (figure 1) to an interpretation (figure 2) which is both managable by the machine and appropriate for first approximations, guesses and extrapolations. Later, we expect to employ graphical innuendoes for the purpose of having the machine recognize attributes which have to do with the user's attitude toward his own project, his confidence in a solution and the like.

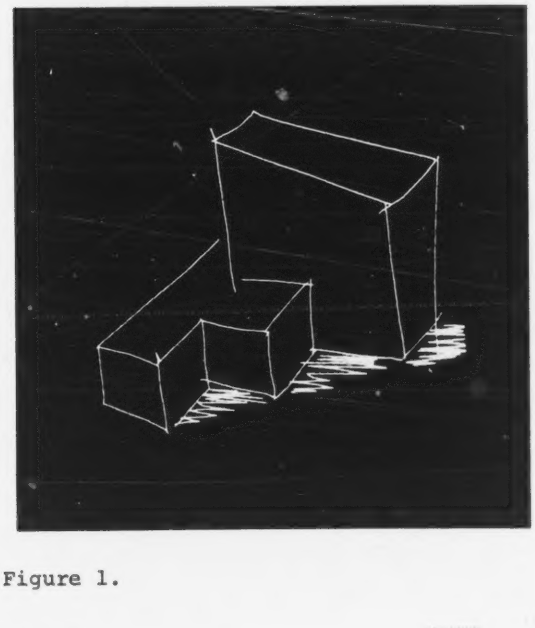


Figure 1.

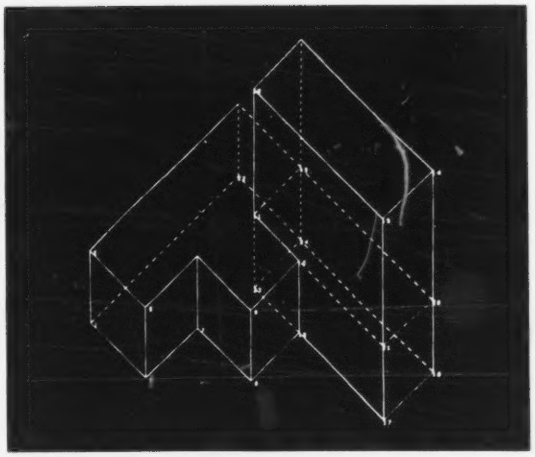


Figure 2.

We believe that HUNCH will have general applicability as a front end to computer systems that require the graphical input of ideas which are not well formed. It should have particular importance for architectural applications inasmuch as present day computer applications are always hampered by the means of imput. The architect interested in computer-aided design techniques must either 1) do a design away from the machine, and at some level of completion initiate the usually clumsy procedures necessary to make it readable by the machine; or 2) must stymie his own design behavior and subject himself to drawing techniques which are inappropriate for "creative" thought. Neither is suitable.

Within the next two years, HUNCH is expected to handle true sketches (figure 3), drawings marked by inaccuracies, missing information and even coffee stains. We propose to do this by: 1) providing the user with a broad range of amenable hardware interfaces with the machine; 2) developing programs that get to know the particular user better and better; 3) creating an inference-making system that capitalizes upon a history of encounters with many users as well as with the particular user.

The following pages should be viewed as an interim report.

Configuration

We start with a description of the configuration of our hardware because we believe that each device has unique operational characteristics built into it.

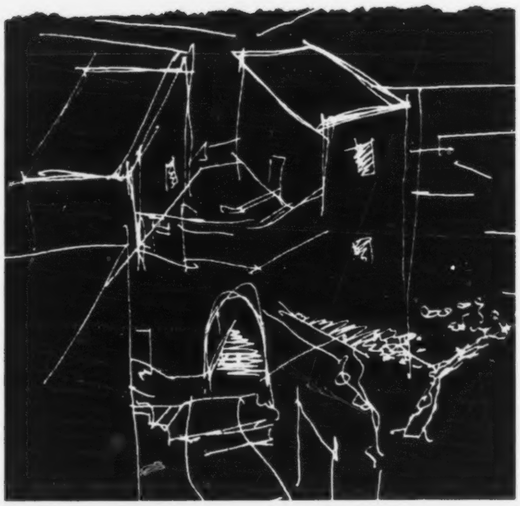
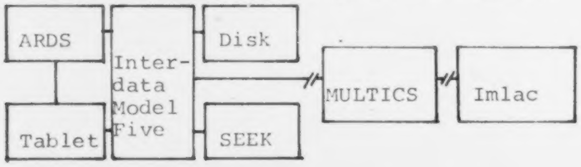


Figure 3

We depend very heavily upon these inherent features for the purpose of recognition as well as of intensive, congenial interaction. The hardware described is a subset of what we call "The Architecture Machine" (figure 4).

The diagram illustrates the subset of The Architecture Machine used for HUNCH as well as the interconnections among the seven operating elements: a Sylvania Tablet, an Advanced Remote Display Station (ARDS), an Interdata model 5 minicomputer, a Diskstor disk, the MULTICS time-sharing system, an IMLAC display unit and a three dimensional positioning device called SEEK. The reader should note that this configuration is highly redundant and, while it employs a plurality of devices, it is marked by a very low cost, approximately $40,000 purchase price.



Sylvania Tablet

The Sylvania Tablet, with its stylus, is the primary input medium of the system (figure 5). The tablet operates in a manner that is crucial to HUNCH. It issues to the minicomputer a constant number of X and Y (and even Z) coordinates per second (in our case 200 hundred per second). This constant rate acts as a form of a clock.

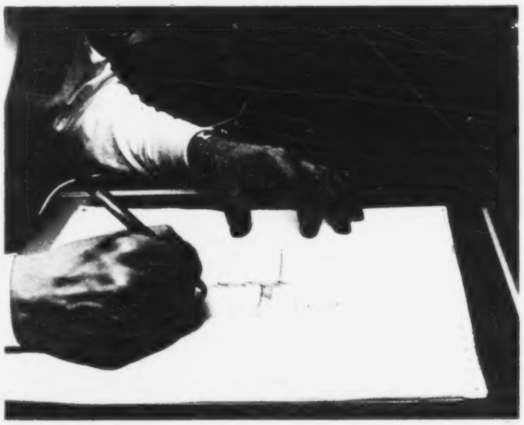


Figure 5

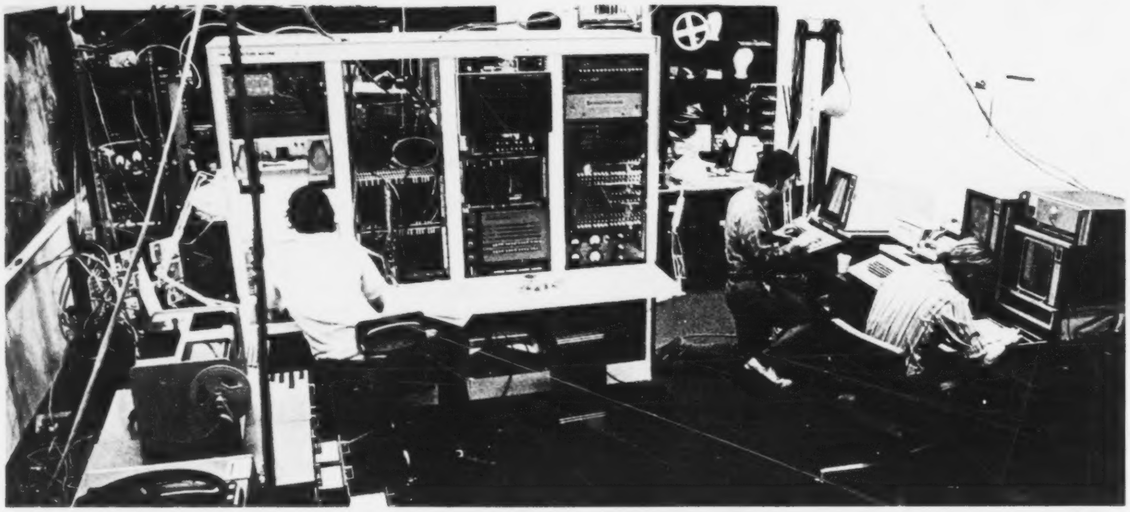


Figure 4

It means that lines drawn slowly will have digitized points closely spaced, whereas lines drawn rapidly will have them more dispersed. As a result, we have a built-in record of the speed at which each part of a drawing is created. We subsequently employ this parameter as a major criterion for determining the user's graphical intentions: "did he mean this to be ... a straight line, a square, a corner, etc?". In effect, we are correlating the user's speed of drawing with his purposefulness.

We also associate intentions with the user's pressure upon the stylus. This feature has been added to the Sylvania Tablet by Wade Shaw as part of his Electrical Engineering Thesis, Textural Input and Definition for Graphic Display. A pressure sensing gage placed within the shaft of the pen measures how hard the user is pressing down. When connected with the focus control of the display, this feature simulates pushing harder on a pencil to get a blacker line. We believe that this is particularly important to sketching because it is quite common to overtrace lines, and thus without erasing, to make the most up-to-date lines emphatically dark.

It is important to note that both speed and pressure provide inputs which would not really be available to an onlooking human, especially if he were looking at the sketch after the fact. Some argue that it is more appropriate or meaningful to artificial intelligence to use only those cues available to humans. We don't.

The tablet has two further important features: First, it has a transparent surface which permits it to be used vertically in front of the display with the minor inconvenience of a half inch paralax (figure 6).

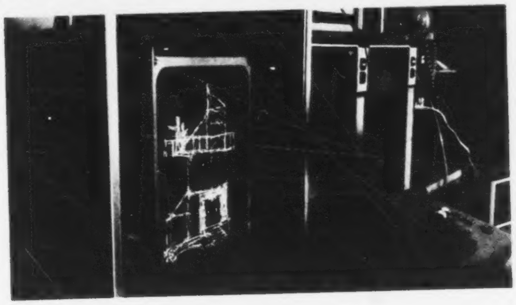


Figure 6

This provides an ability for drawing without the computations necessary for pen tracking (which is necessary for light pens). Second, it has a limited three dimensional capability because it can record three levels of Z (where the range of each level is variable with a screw driver). At this time we make only limited use of this last feature (for example, we determine the probable beginnings and ends of pictures and opportune moments to write information on the disk).

Advanced Remote Display Station

ARDS was the first storage tube system developed (figure 7). The advantage of a storage tube is that it maintains the image on the face of the scope without "refreshing" it and thus without the associated computations necessary to continually redraw the image. (Hence its convenience to time-sharing.) Its drawback is its resulting inability to locally erase, that is to remove a part of the picture without erasing the whole and redrawing it.

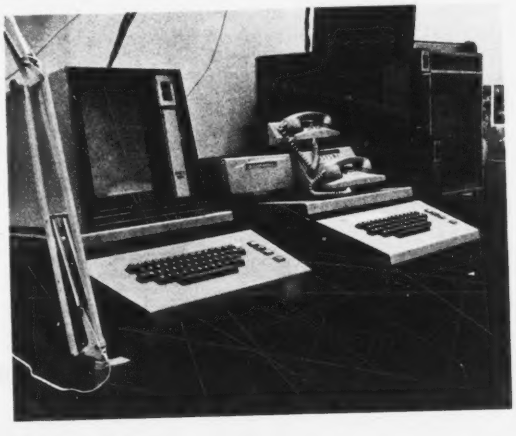


Figure 7

This does not pose a problem in our context; consider whether you can locally erase with a felt tip pen, or how often you erase pencil lines. Furthermore, a storage tube allows an unlimited number of vectors to be displayed (in contrast to the more expensive "dynamic displays" that allow only a few seconds of sketching before flicker sets in because so many points must be continually drawn).

Storage tubes have the ability to "write thru". This mode of operation can be initiated under computer control. It affects a low beam voltage which produces vectors that are not stored. Therefore, with a minicomputer at hand you can partially circumvent the local erase problem and maintain a certain number of vectors dynamically -- we employ this for editing and moving about elements of the picture. (It should be noted that this feature varies dramatically with the brand of storage display station. The ARDS is the least appropriate in that it steps vectors, rather than sweeping them, and hence cannot display lines as fast as other brands.) A drawback of of write thru mode is that storage tubes are inherently dim, write thru is even dimmer, and consequently when using it the user must operate in a partially darkened room.

Interdata

The Interdata Model 5 computer is typical of any good minicomputer; it is very fast and provides very cheap computing power. The processor and memory is similar to that employed for HUNCH and can be purchased for $10,000. Since the Interdata is faster than both the Tablet and the ARDS, it can perform background operations, in effect, dealing with the sketch in parallel with the user creating it. Its drawback (not inherent in the computer) is its comparatively small memory. Given 200 points per second (4800 bits per second), a 16K memory is filled in only 16 seconds of sketching; hence an auxiliary memory is necessary.

Diskstor

The Diskstor is a removable disk pack system, with single surface disks (512K bytes per side) and fixed heads, one per track. The fixed heads eliminate "seek time" making the disk extremely fast. This feature permits the disk to accept the initial sketch as if the tablet were connected directly to core memory. With the disk, the user can draw continuously for over an hour. However, since nothing is stored when the pen is lifted off the tablet, this means about four or five hours of natural sketching.

MULTICS

MULTICS is a time-sharing system developed by MIT's Project MAC on a GE645 computer. It has powerful file-sharing abilities and caters heavily to systems programming.

It may be argued that time-sharing will not be cost effective when, in ten or twenty years, minicomputers sell for $200. Its future role may well be that of communications and of sharing large data bases, and then only by machines (ie minicomputers)not people. Nevertheless, presently it is particularly useful because it makes available high level languages and their software support: these usually are not available on minicomputers. It is for this reason that we use MULTICS. The list processing and recursive features of the MULTICS version of PL/1 are necessary for mapping a perspective sketch from two dimensions.

We also employ the time-sharing system as a communications medium between the ARDS Interdata display and the IMLAC.

IMLAC

An IMLAC is a display unit which has a self-contained processor memory and display processor that can support up to inches of vectors (depending upon available memory and other options). It has recently been added to the HUNCH configuration in order to experiment with those dynamic features usually available only on very expensive display units. At present we are programming it to present the results of the mapping into three dimensions performed on MULTICS. This includes rotations, translations, etc., and a limited ability to change proportions by moving planes while keeping the topology constant.

SEEK

SEEK is a homemade, three dimensional positioning device that can build physical models using predescribed blocks of wood (figure 8).

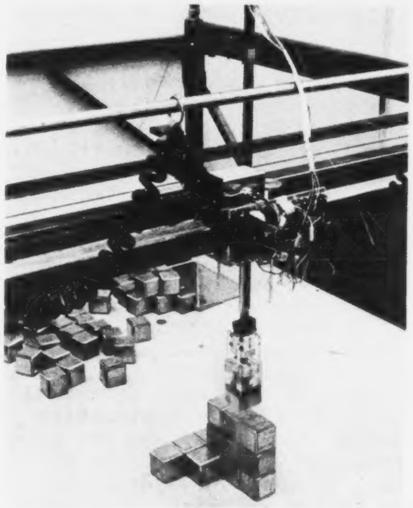


Figure 8.

It receives its instructions from the Interdata which in turn has received from MULTICS the X,Y, and Z coordinates of the centroids of the blocks necessary to best approximate the sketched image. In some sense it is a punchline to the demonstration program we employ to demonstrate the present workings of HUNCH; it is not an integral part of sketch recognition. However, consider the spectacle: you sketch a perspective of an assemblage of housing units; behind you a machine is building them. You change your sketch; the physical model is changed.

Operations

In this section we take some liberty in mingling the present and future tense with respect to what is and what is about to be operational. A great deal of HUNCH is presently working and demonstrable at the lowest levels of recognition; very little is developed at the upper end. The operations are carried out in a somewhat sequential manner and are presented following that order. However, it is important to recognize that the initial data and the subsequent transformations are saved on disk. This permits interactive reexamination of the data in order to build evidence that "he meant this"or "he meant that". This contradicts the sequential nature of the following presentation and the present demonstration program. Being able to look back, to collect more evidence, and to alter previous (now proved erroneous) decisions are all crucial to sketch recognition.

Initiation

HUNCH is being developed to be trained (we use the word advisedly) by a particular user. This training will occur both implicitly and explicitly through reinforcing an evergrowing model of the user and his method of work (particularly his method of drawing). In order to start the program, some initialization is necessary when the user and HUNCH first meet. No two people draw in the same manner and HUNCH would flounder without some means of correlating the pressure and speed of a given user with his graphical intentions. In the early days we saw this dramatically demonstrated when the initiation procedures did not exist and the program was tuned to the hand of its chief programmer, Mr. James Taggart. If another member of the Architecture Machine Group would try to demonstrate HUNCH, the result would be embarassing.

Therefore, a simple scenario precedes the first sitting. "Draw me a square," says HUNCH. The user draws a square and HUNCH proceeds to vary its own parameters of speed and pressure until it manages to compose a square out of the stream (let's say 600 hundred or so) of x's and y's. Then it asks in turn for a fast square and slow square. Eventually enough parameters will have been set to enable HUNCH to proceed with the different levels of recognition and data compression.

Diagrams

After initialization, the first operation which must be performed on the stream of data (ie:sketch) is the recognition necessary to separate diagrammatic elements from projections (either orthographic or perspective). In projections, the vectors delineating a figure represent the intersection of planes or delimiting contours of physical bodies; in diagrams, they do not. Letters of the alphabet, arrows and symbolic notations are examples of diagrammatic elements. Plans,sections and perspectives are typical projections. At present we handle only one kind of diagram -- the squiggle. We anticipate handling many others including a character recognition ability.

"Squiggles" must be distinguished from intentional wavy lines. This can be done with uncanny accuracy simply by analysing the speed and the accelerations at the corners. Once recognized as an authentic squiggle, we consider it to be only one of two things: 1) shading; 2) a rubbing out gesture.

It is important to recognize shading, not only to avoid processing it "projectively", but also to have it as future evidence for guesses about solidarity and orientation (figures 9 and 10). The direction of the sun, the parallelism of its rays, and the interpositioning necessary for shadows are simple concepts, easily included in programs (though we would prefer that the programs could develop the concepts themselves). Such an analysis affords excellent evidences for locating the ground plane or perceiving depth.

The rubbing out gesture is particularly important for editing. This technique of rubbing out using squiggles, is found as far back as 1969 in the Grail Language[4] developed by the Rand Corporation. It is distinguished from shading by con-

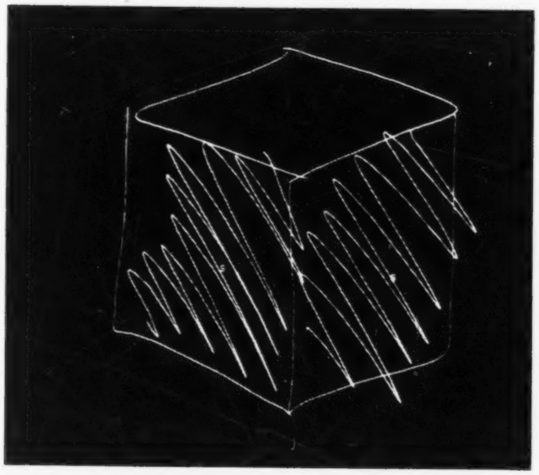


Figure 9.

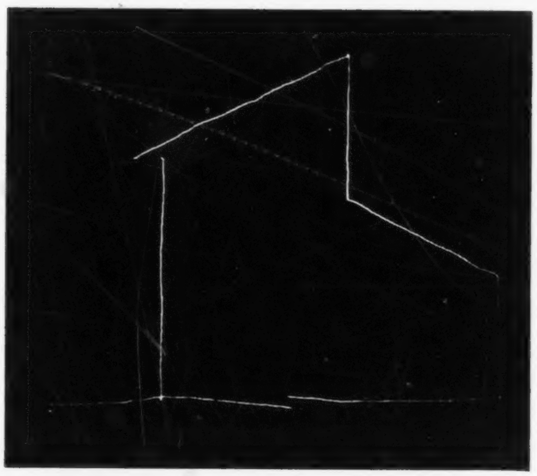


Figure 11.

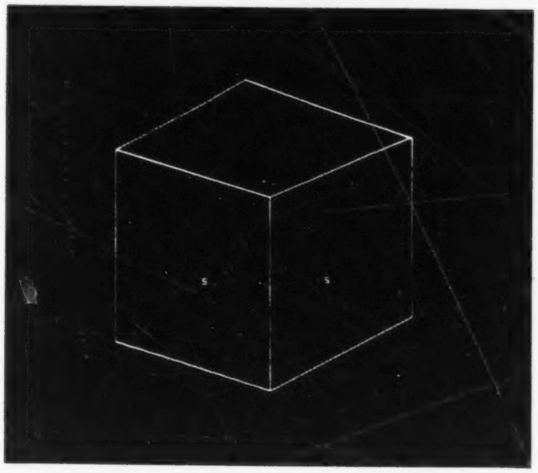


Figure 10.

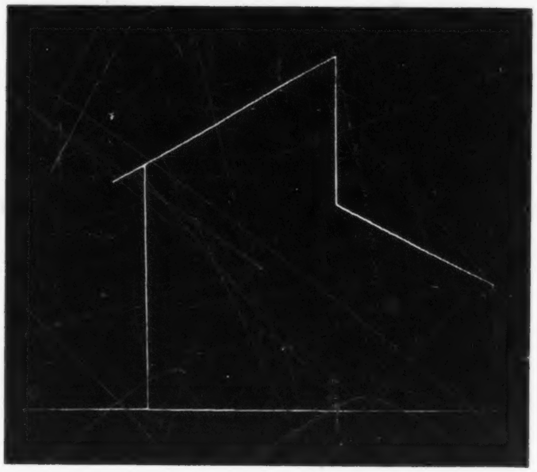


Figure 12.

sidering when (in the sequence of constructing or editing an image) it is drawn, and by the location of its centroid (ie: is it on top of a line or within a surface?)

Data Compression

Data compression is a major element in the presently operating version of HUNCH. Figure 11 represents 4128 core locations as raw data; figure 12, the same drawing, represents 128 locations after data compression. This operation is important for subsequent inference making and for transmitting the image to the time-sharing system at 1200 bits per second. The adjacent image would take half a minute to transmit unstraightened, and less than a second after data compression.

Line straightening is not a trival operation. The problem is that decisions on the straightness of a line cannot be made by looking only at a given point and its immediate neighbors (let's say within an eighth inch radius). Local nicks and bumps caused by a shaking of the wrist, a bump on the paper, or simple noise in the tablet could indicate corners that were indeed unintended. Instead, it is necessary to connect, for example, every tenth point and look for violent changes in angle (arctangent) among the resulting line segments.

This procedure is greatly assisted by considering the speed of drawing; a hastily drawn square with rounded corners (figure 13) will be assumed to be a closed straight line figure, whereas one drawn slowly, of identical shape, will be interpreted as a figure meant , to be rounded.

In fact, it is interesting to note that a stream of incoming graphical data can be examined solely for peaks and troughs in speed and that if the points of slowest velocity were interconnected, the resulting image has about 80% fit with the intended image!

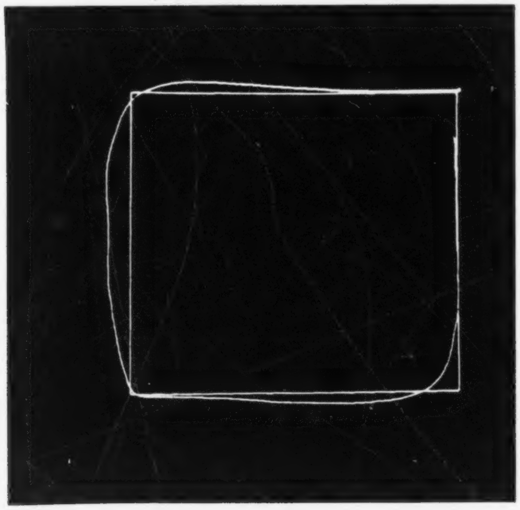


Figure 13.

Curve Recognition

We have ignored curves for a long time. They are not indiginous to architecture; we don't believe that sophisticated computer graphics techniques will lead to a proliferation of Gaudiesque architecture (in fact we might want to discourage it). However, in any demonstration we have ever conducted, the visitor/user inevitably draws cruves. Thus we are willing to recognize them, but in no sense to try to "fit"them.

Fortuitously, as a direct result of the above data compression procedures, curve recognition is relatively simple. The method we employ is to slightly vary those parameters that control the importance of speed. If the user intended to draw an actual curve (versus a wobbly straight line) the straightened interpretation will be dramatically different when different speed factors are employed. If a user intended to draw an oval, the straightened version is almost unpredictable: we can be assured, however, that each straightened version will be markedly different from the others. Figure 14 shows a curve straightened employing three different weightings for the speed parameter. Figure 15 shows a curve that has been recognized and subsequently left unstraightened. In effect, what we are capitalizing upon is the results furnished by a procedure given a task it was not meant to handle.

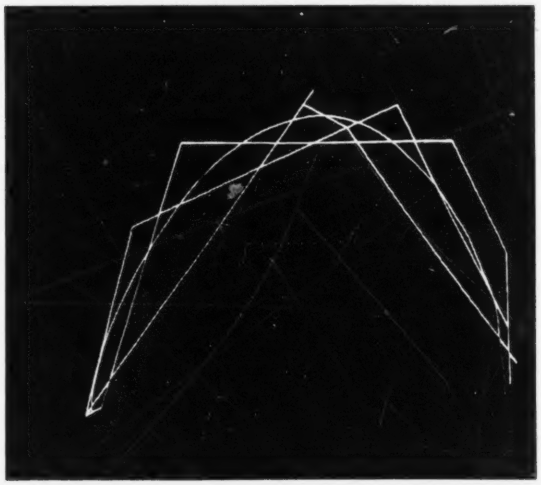


Figure 14.

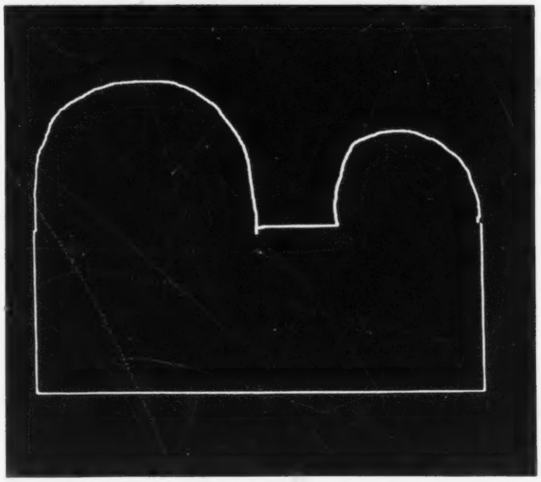


Figure 15.

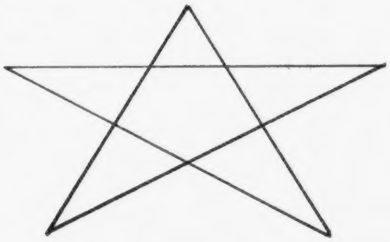
Latching

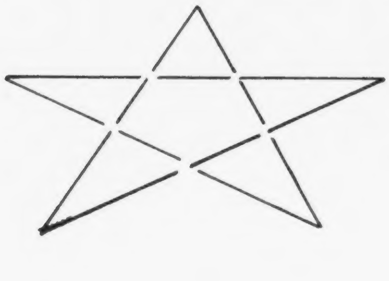
Our first approach was that the latching of lines should be purely a function of velocity. Two lines that almost meet, but that were drawn slowly (where slow and fast are in the vernacular of the particular user) were not to be connected.

However, this approach turned out to be wrong when users composed small, intricate drawings. The mullions of a window, for example, would inevitably latch onto the corner of the sill, offering absurd interpretations of the sketch. The error resulted from the philospohical oversight of not looking for all the candidates (for latching, in this case) and choosing the most appropriate (or none at all). There are obvious and important determinants for latching beyond simply speed: is it a connected body? is the shape closing upon itself? what does this do to horizontality and verticality? and so on. The result is a much more timid "latcher", but a much more correct one. (More farreaching consequences are discussed in Section IV.)

Intersections

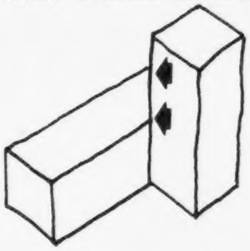
After a sequence of lines have been straightened (ie:compressed), the lines are represented only by their end points (See Appendix). HUNCH then locates intersections, and breaks the intersecting lines into line segments. Thus a five pointed star results in fifteen line segments with ten end points.

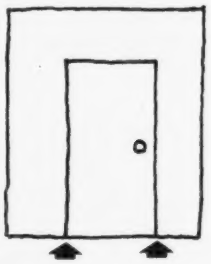




The problem that we suspect may arise will be when we want to recognize a star or "starness" which is certainly intrinsically more than a five sided "thing".

Nevertheless, in some contexts, intersections are crucial, especially when a line segment meets another line at other than an end point. This occurrence results in a so-called T joint. This is also a problem because an almost meeting T or an overshot T is made to end exactly at the line (as a function of velocity and pressure). It is interesting to note, however, that non-perpendicular T's are often unlatched by later "mapping" operations since they are good evidence that one body or plane lies behind the other.





Inference Making

In the jargon of Sketchpad[5] and Sketchpad III [6] making inferences is "constraint resolution"; in our case, it is handled implicitly. We consider, for the time being, only four types of inferences that the machine makes without the user's explicit request: 1)horizontal/vertical, 2) parallel/perpendicular, 3) continuities, 4)overtracing.

When almost horizontal and almost vertical lines are made plumb, the picture takes on a drammatically different character. This is particularly true inasmuch as the preceeding routines, straightening and latching, frequently operate at the expense of intended horizontality and verticality as dramatized in figures 16, 17 and 18. The operation is especially important in the context of architecture, where verticality and horizontality have structural meaning. In areas of industrial or city design, this operation would have less propriety.

Parallelism and perpendicularity, on the other hand, are more context dependent. Inferring that two almost parallel or perpendicular lines were meant to be parallel or perpendicular is more difficult. This is because the positional relationship between two lines must be considered. In the case of parallelism,

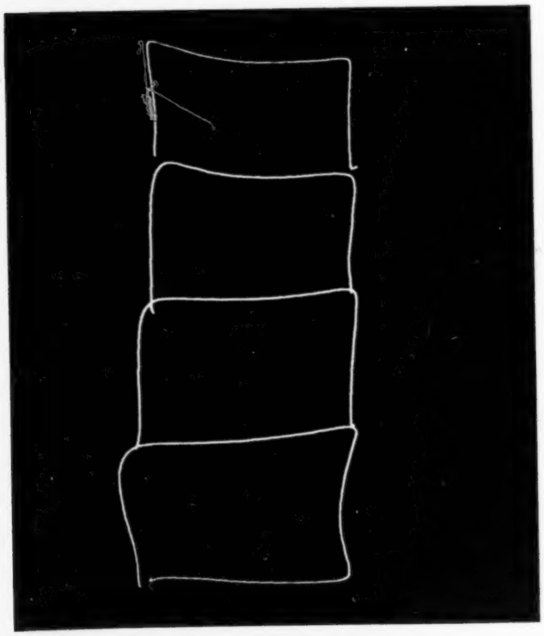


Figure 16

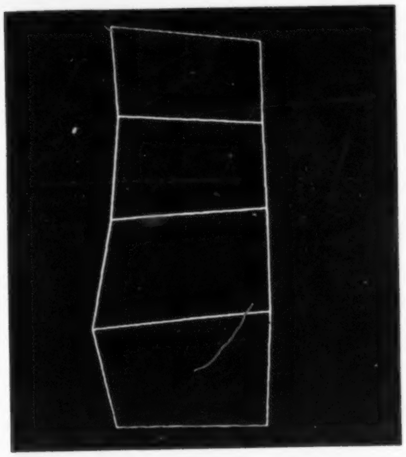


Figure 17

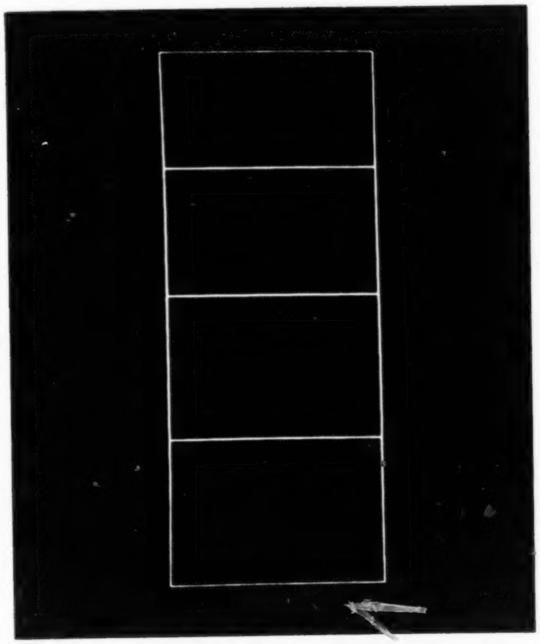
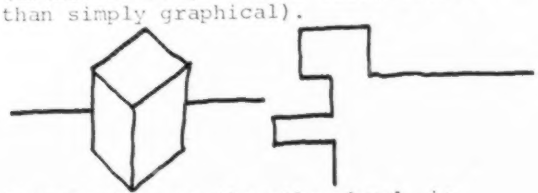


Figure 18.

for example, the paradox exists that distant lines that happen to be nearly parallel are less likely to be intended to be parallel (especially if they are short and many other lines intervene); however, it is more difficult to draw lines parallel when they are far apart, no matter how carefully it is done, (again, especially when they are short). The problem is only manageable by the fact that overenthusiastic orthogonalizing and parallelizing does not produce drastic errors (as does a nontimid latcher).

Continuities are once again rather architectural in nature. They are heavily reinforced by the sequence of the drawing and have very little to do with speed.

Inferring continuities is a good example of where it is necessary to go back to the original raw data because intended continuities are often broken by straightening, horizontalizing and the like. The computation problem is messy as it demands extending each line segment within the bounds of the picture and then making good guesses at intentions of co-lineality. This operation can be greatly reinforced by the knowing of the user and his methods of work (architectural, in this case, rather than simply graphical).



Overtracing, on the other hand, is straightfoward because it is very much a function of velocity, sequence and pressure. Two lines drawn side by side, one after the other, very slowly, are probably intended to be two closely spaced parallel lines. Two lines which are drawn rapidly in succession and are almost coincident are probably meant to be a single line, emphasized or corrected. Lines drawn in succession, but one over the other with greater force can be viewed as a form of implicit editing (a good guess would be that the overtracing implied erasure).

Editing

There are two forms of editing: altering your drawing and altering the machine's interpretation of your drawing. Some people might argue that the latter results only from the ineptitude of the machine and a good "sketch recognizer" would not need that sort of editing.

On the contrary, we believe that the editor, over the next two years, will evolve into one of the most important parts of the system, not to facilitate correcting a stupid machine, but to include some features of learning. The editor should ask better and better questions. It should analyse erroneous interpretations as a means of altering its model of the user and of reinforcing its propensity to be a surrogate hand/pencil.

At present, the editor is a modest facility for graphical changes of either kind. It permits adding and subtracting lines and corners, moving segments of the picture (figure 19, time lapse photograph) and explicitly evoking any of the routines included in inference making. It exercizes write thru mode, which, in the case of ARDS, can support four or five vectors of modest length. (This limitation is not true for other brands of storage tubes.)

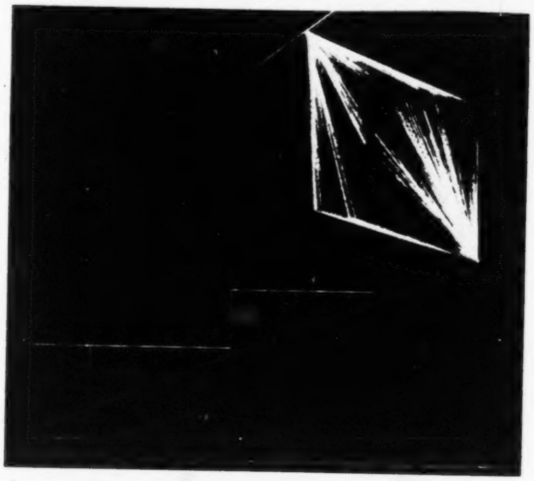


Figure 19.

Communications

All the operations discussed above take place in the Interdata, using only local computing power; they are programmed in Interdata machine language, a 360-like language. Most of the remaining operations require higher level languages and are performed on a remote time-sharing system, MULTICS.

Communications operations are utilities that make the Interdata look like a 2741 typewriter terminal (135 bits per second) or like a stand alone ARDS (1200 bits per second), depending upon which port is available (it prefers the latter). In one case, the compressed data is transmitted in EBCIC, in the other USACII: the user and the other operations are unaware of which is being used. At present, the only requirement for the user is that he dial up MULTICS by phone (shortly this will be replaced with an automatic dial up system that will work under computer control).

Projection Recognizer

At MULTICS, the operations no longer take place in "real time", but are at the mercy of the time of day, the number of other users and the load on the system. All programming at MULTICS is done in a MULTICS version of PL/1.

The projection recognizer is fundamentally a branching procedure that seeks to recognize what kind of drawing it is receiving. (Note that this entire problem could be easily circumvented by simply requiring the minor inconvenience of a label, but in keeping with our concept of wanting the user to be no more categorical than with an onlooking human, we feel that the following recognition routines are neccessary.)

The first task is to determine whether it is a perspective or an orthographic projection. This branching procedure is relatively simple because it can be handled by supporting or refuting the candidacy of its being a perspective. You can look for a horizon line, points of infinite intersection, or try to establish a picture plane or viewing position. The more complicated the image, the easier it is to gather convincing evidence and make a failsafe decision.

If it is an orthographic projection, the question is whether it is a vertical section, a horizontal section (plan) or an axonometric. The axonometric is the easiest to recognize and, if found, is subsequently treated like a perspective, with the onserver at infinity. Plans and sections are the most difficult to distinguish. They depend heavily upon our knowledge of the real world and associated implications. For example, floors are usually horizontal and walls vertical, stairs are a give-away and roofs slope for a purpose. There are, nontheless, cases where even the most experienced architect would have difficulty deciding whether he was looking at a plan, or a section. We do not expect our program to handle these cases. We expect it to ask, and like the editor, to improve.

If the transmitted image is indeed an orthographic projection, the next question is: what is its scale? As in the problem of distinguishing plans from sections, a knowledge of the world must be imbedded in the program in the form of heuristics, rules of thumb. While there are give-aways like figures and trees, most drawings are given scale by a knowledge of the problem at hand or by association with, for example, a winding street seen in plan or a facade in section.

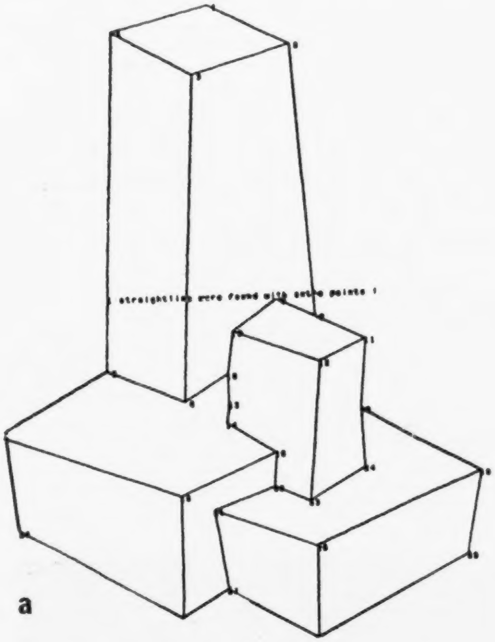
If the picture has been made out to be a perspective the program proceeds directly to a process of mapping into three dimensions.

Mapping Perspectives

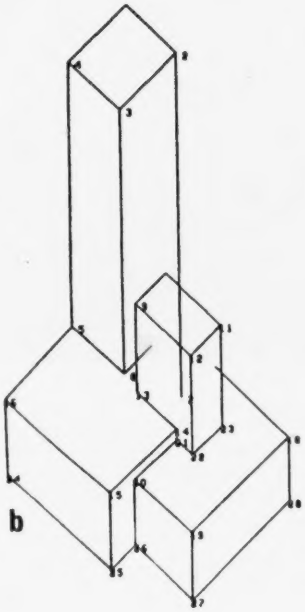
The strategy for mapping into three dimensions results from the authors' previous experiences with machine vision[7], and the indiginous character of perspective drawing at the level of a sketch. The problem is to map a two dimensional image into three dimensions, and to handle all the ambiguities that exist for even the human observer. The solution is not deterministic in any sense; guesses and assumptions are necessary. The reader familiar with problems of machine vision should recofnize a major difference between a sketched perspective and an image acquired by a device like a vidisector or a fly spot scanner: that is, in the sketched image, we inherently know the sequence of lines.

The fundamental and well documented program of Guzman[8] develops evidence for connecting bodies (the initial scene being composed of separate, assumed unrelated regions). Our efforts of mapping into three dimensions postulates the opposite. That is, we assume the scene (ie: the perspective) is one single body in one single plane (which is, of course, impossible). Heuristics are then used to break them apart and separate the regions in terms of their depth in the scene. T joints, diagonals and parallelograms are the main sources of evidence for positioning planes. At present, we assume a flat ground plane.

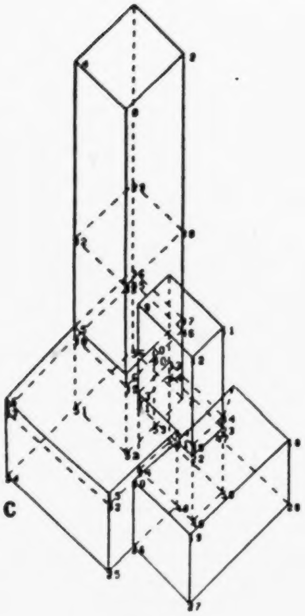
The following four illustrations (photostat reversals of photographs from the ARDS) describe the four stages of mapping a rather complex scene into three dimensions.



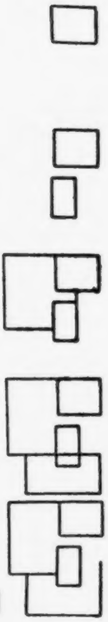
a



b



c



d

The description was transmitted to MULTICS from the Interdata (a), normalized (b), mapped (c), and described in terms of plans (d). You will notice that all the hidden lines are filled in, including adding points that represent cuts through the different levels (not inherent in a description of the physical body.) This results in a mishmash of unreadable numbers and dotted lines that are being displayed only for the purposes of debugging. (The observant reader will notice a small error at the bottommost level.)

Mapping Sections

In the case of orthographic projections like plans and sections, mapping into three dimensions is fundamentally a problem of joining; for example connecting a section with a plan, several plans, or several sections. At this writing work has not been started on this problem. We expect this work to be particularly important because when doodling plans and sections, one often describes geometric impossibilities. At the same time, there is no minimum of orthographic views which can unambiguously describe any scene. The result is that: a) many views may be necessary, b) modelling in three dimensions may mean carrying several alternatives, c) heuristics will be necessary to limit the number of these alternatives.

Massaging

Our interest in massaging a three dimensional body results partly from the presence of the Imlac display unit capable of handling this task. It is important because the mapping routines are often performed at the expense of the intended proportions. Therefore, we employ the Imlac as a display device for rotations, translations and the like. It has a singular means of input (to be a light pen, but presently a keyboard) for changing the proportions, but not the topology of a given figure. The Imlac communicates directly with MULTICS, not the Interdata. It manipulates only the three dimensional model (figure 20).

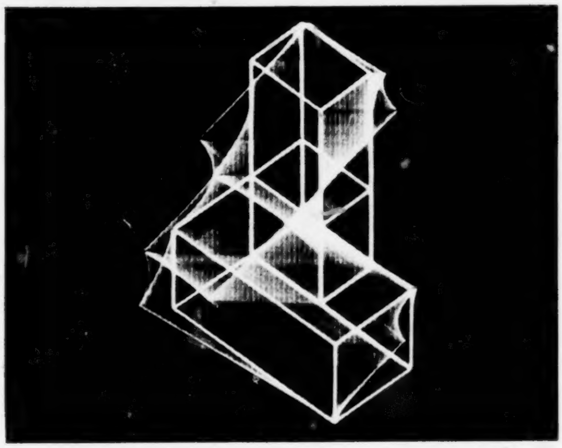


Figure 20.

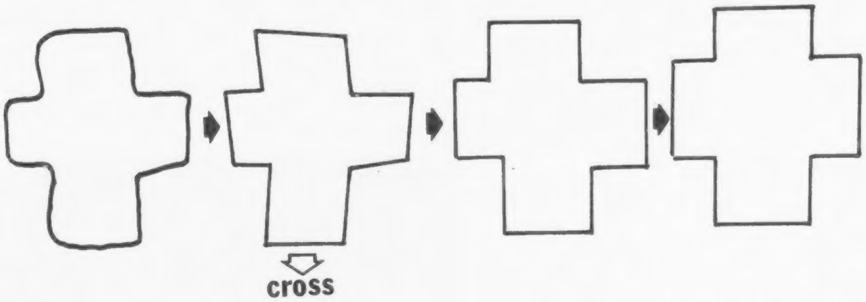
Building in Three Dimensions

Following a successful mapping into three dimensions and perhaps some massaging, routines are evoked at the MULTICS end that compute the best approximation of the figure(s) which can be built within SEEK's repetoire of two inch cubes. The X,Y and Z locations of the centroids are sent back to the Interdata which drives the apparatus to build it (see figure 8).

Shape Recognition

At this time, with graphical transformations in some sense under control, we forsee our major work being in the area of shape recognition. While we are describing the aspect of recognition at the end of Operations, it may result in being an initial step of recognition, one providing evidence to other operations.

For example, the following diagram depicts the present sequence of graphical treatments applied to twelve lines. The fact that the four wings have (in our present scheme of things) no way of becoming the same size, though that was what was probably meant, might suggest that we simply add an inference making feature that looks for the repetition of line lengths (which we could do but which might lead to looking for repetition of shapes, volumes, line spacing and so on ad nauseam).



We suspect that a more appropriate approach would be to look, in this case, for "crossness". The very concept of "cross" furnishes many of the graphical inferences that until now have been handled in some sense brutally.

Comments

Suggestor/Critcizer

So far we have presented operations that perform tasks, through either heuristics or rules, with some confidence that they will eventually arrive at a single, best of all possible, answer or guess. However, while we have been willing to make erroneous judgements (ie: have programs make errors), look back to original data, try to recover, and even draw benefits from the error, we have not so far viewed the problem as having a multiplicity of "reasonable" interpretations. To meet this deficiency, we propose that two computing entities are necessary in all operations: those that recommend "reasonable candidates", and those that review them. This may mean carrying several interpretations a long way through the process of recognition before they are disqualified.

One major advantage of this bipartition is that routines can be allowed more aggressive interpretations, even wild guesses.

The implementation of this notion of suggestor/criticizor is not a dramatic departure from our present operational model. The present routines will be turned into the suggestors and simply made less timid. Criticizors, meanwhile are new programs that must include both the heuristics for selections and the arrangement of the storage of candidates. We envision this collecting and sorting of interpretations as a tree that gets bigger in the middle and diminishes toward the end, transmitting only a few candidates (conceivably just one) to MULTICS. It is unclear to us at this time, how much suggesting and criticizing goes on between the local and the satellite computers.

Modelling the User

Gordon Pask[9] has proposed that we must deal with three levels of models. The first level deals with HUNCH's model of the user ranging between his manner of drawing, (speed,pressure,etc.) and his attitudes toward architecture. This model is for the purpose of faster and more complete understanding. When a user does what HUNCH predicts he will do (for example by recognizing his propensity for repeating elements), it can shortcircuit a great deal of inference making, or at least, reinforce it. The success of this model can be easily measured as a function of the closeness of fit between between the anticipated event and the actual intention. In no sense should such a model be failsafe or infallable. That is the wrong attitude toward the problem. While at the onset such a model would appear passive and thus not exhibit inept behavior, as soon as it became active it would make many errors and be expected to improve from them.

The next more complicated level of modelling is HUNCH's model of the designer's model of it. This is important for inference making becuase one tends to leave implicit only those issues which one assumes that the other party understands. In effect, this model grows out of a prosperity of matches between the inferred information and the intended information. If HUNCH infers a square and you meant a square, the procedures that led to the assumption are reinforced as a function of the kind of drawing and its context (the most difficult part).

The last level of models may appear overly circuitous. It is HUNCH's model of the user's model of its model of him. We suspect that this level will be particularly important when we approach a more intelligent recognition system, because it is the convergence of this model with the first level (HUNCH's model of the user) that leads to an acquaintance into a partnership.

At present, only modest implementations exist. Beyond the purely graphical inferences from simple methods of the user, we are working on a measure of intentions at a more global scale. "Rapidly formed lines appear to be the designer's context or background, and they represent elements about which he either knows a great deal or almost nothing at all!! When lines are formed at lower velocities, the interaction between the designer's concept and the machine's model of the concept appears to be most revealing. Crookedness appears, and there are uncertain gestures and highly reworked lines: this all may represent (perhaps semantic) dispositions toward a design such as being "concerned about", "sure of", "puzzled by" and so forth.[10]

Notes and References

1. HUNCH is being developed by the Architecture Machine Group, established in 1967 by Professors Leon B. Groisser and Nicholas Negroponte of the Department of Architecture, M.I.T. Mr. James Taggart has been the protagonist-programmer, assisted by Miss Cindy O'Connel and Mr. Michael Miller.

2. Computer Aided Participatory Architecture is a proposal to the National Science Foundation that has been reprinted. It is available through The Architecture Machine Group, Room 9-520, MIT, Cambridge, Massachusetts, ($5.00).

3. Negroponte, N. The Architecture Machine, M.I.T. Press, 1970; Cambridge, Massachusetts, p.19.

4. T.O. Ellis, J.F. Heafner and W.L. Sibley, The Grail Project: an Experiment in Man-Machine Communications, The Rand Corporation, Memorandum RM-5999-ARPA, September, 1969.

5. I.E. Sutherland, "Sketchpad: A Man-Machine Graphical Communications System", AFIPS Proceedings, 1963.

6. T.E. Johnson, "Sketchpad III: A Computer Program for Drawing in Three Dimensions", AFIPS Proceedings, 1963.

7. Machine Vision of Models of the Physical Environment, The Architecture Machine Group, NSF Proposal 1969 (reprints no longer available).

8. Guzman, A., "Decomposition of a Visual Scene into Three-Dimensional Bodies", Automatic Interpretation and Classification of Images, Grasselli (Ed.) pp. 243-276, Academic Press, New York, 1969.

9. Through private communication.

10. N. Negroponte and L.B. Groisser, "The Semantics of Architecture Machine", Architectural Forum (US), October 1970 and Architectural Design (GB), September 1969.

MACHINE-AIDED EVALUATION OF ALTERNATIVE DESIGNS

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Abstract

A man-machine interactive system, Kanshiki, is designed to augment and sharpen man's judgment in evaluating alternative designs or plans of action. Both factual and value-oriented information are needed, and can be treated consistently and systematically, in evaluating possible consequences of proposed alternatives. The adequacy of criteria used can be questioned and their definition and structure modified, through interaction, to explore many trade-off implications and judgmental interpretations. With Kanshiki, man will be able to examine a much larger number of alternatives, weighing many different factors, than he normally can.

Introduction

The major concern in this paper is how to evaluate programs with value-laden issues such as those that are directed toward improving the "quality of life"--any programs, in fact, having socioeconomic, ecological, political, or psychological implications. We all know that technology has given us mixed blessings and that we are paying a high price for some of the "benefits" gained. Because technology often intermeshes intimately with the social fabric, we are becoming more and more aware of the necessity for long-range planning and for assessing possible consequences of our actions. It is in this planning and problem-solving context that I am going to discuss a technique of evaluation.

To place the evaluative process in a proper setting, I shall first present a simple characterization of the four decision steps commonly found in planning and problem solving. They are:

- Define the objectives and set appropriate criteria.
- Generate alternative courses of action.
- Identify or estimate possible consequences of each alternative.
- Evaluate the consequences in terms of the criteria and choose the alternative which best achieves the objectives.

Since the initial attempt at defining objectives and criteria is often inadequate and incomplete, these steps are usually repeated. The iterative nature of the process is shown schematically in Figure 1.

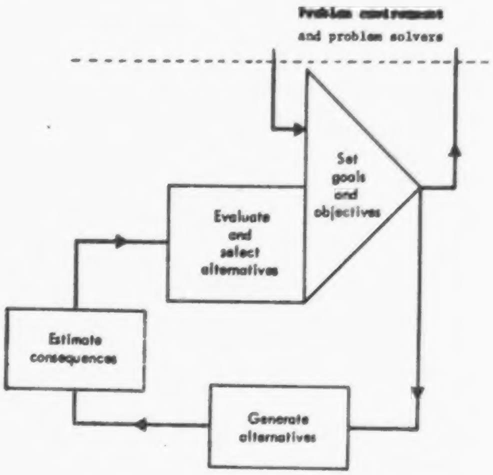


Figure 1. Iterative Decision Steps

The man-machine system, Gaku, deals with these steps in detail and in many levels of planning, from a vague and aggregated conceptual stage to a concrete and detailed action-oriented stage (Hormann, 1971, Part I and II). With this simplified background, let us assume that many alternatives have been generated and their possible consequences estimated and focus our attention on the evaluation phase of planning.

Depending upon the nature of the problem, the evaluation may be performed by the planners, designers, prospective users of the designed system, or a mixed group of all three. For convenience, the more general terms, "decision makers" and "evaluators," will be used.

Difficulty in evaluating alternatives. Problem situations that are complex and ill defined often defy conventional cost/benefit analyses in evaluating alternative courses of action. Major difficulties are discussed below.

- There are many important aspects of life that escape objective measurements. Definitions of "costs" and "benefits" can be expressed in terms of "undesirable aspects" and "desirable aspects," respectively, but they are seldom well defined, much less quantified.
- Even if they are made explicit and quantified, a single "quantitative measure of effectiveness" is seldom adequate to summarize the issues that arise because of the variety of impacts.
- Differences in individual value orientation cause both obvious and subtle divergences in judgment-oriented decision making. Furthermore, such value systems do change over time and in different circumstances, even for the same individual.
- Trade-off implications are complex and confusing even to an experienced decision maker because of the many factors involved and their incommensurable values. Intuitive judgment is seldom reliable in such a situation. When the complexity of the situation exceeds the capacity of man to cope with it, oversimplification and premature conclusion often result (see reference to "cognitive economy" in Hormann, 1971, Part I).
- There is a growing evidence that the likelihood of making "knowledgable" decisions decreases rapidly as number of alternatives and number of criteria are increased (see the typical curves shown in Figure 2 below).

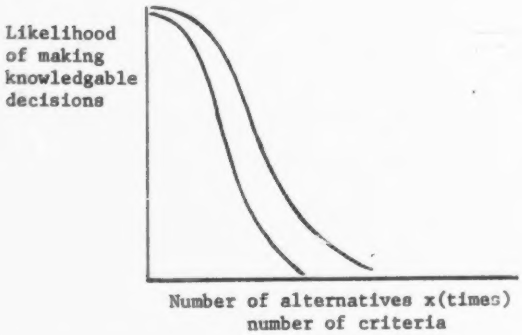


Figure 2. Decision Quality Curves

This seems to be true even with (or because of) a large body of available information. Today's decision maker is often overwhelmed with many pieces of information, each of which may be relevant but not conclusive in itself.

In addition, what the decision maker usually has or receives is a mixture of factual and value-oriented information, qualitative and quantitative measures, and objective and subjective judgments, some of which come to him as "raw" information but many are generated, transformed, and inferred during pre-evaluation and evaluation periods. With these, decision makers face the task of evaluating a large number of alternatives, weighing many factors of both a tangible and intangible nature.

Summary of the approach taken and the rationale. My approach to this type of evaluation task is to use Kanshiki, the man-machine interactive system, which includes a set of techniques and programs as a tool incorporating the "fuzzy-set" concept (Zadeh, 1965). Use of this tool is the major topic of the discussion. A description of the "fuzzy-set" concept will be given later; its meaning suggested by its name will be sufficient now to permit one to understand the rationale behind our approach.

- Although the value-laden issues will never be "solved," i.e., complete agreement on all the issues or universal acceptance of proposed program or design is not possible, the problems are here today and must be dealt with. We must act on the current information available with best techniques available now.
- The approach proposed here is an attempt to bridge the gap between analytical procedures and intuitive procedures; they should be used in a complementary fashion. For this purpose, existing analytical methods and decision aids, such as those developed in utility and decision theories, have been incorporated into Kanshiki to lift many burdens from the decision makers, but more reliance will be placed on judgments and intuition (1), which are elicited by special interactive techniques.

  Since the emphasis is on systematic ayalyses supplemented by intuitive judgment, we strive toward consistency and logical comparability in making relative judgments by providing explicit treatment of indeterminacy and various degrees of imprecision. It may be far more serious to omit a criterion that is believed to be important, just because it cannot be made precise, than to include it at a low level of accuracy.

- Man-machine interactive facilities and techniques, including interactive visual displays, can provide immediate feedback and flexible means of testing and adjusting criteria for evaluation, taking into account intangibles that are often excluded in analytical methods. However, man's judgment of alternatives typically becomes less reliable when multiple criteria of varying importance must be concurrently considered. Kanshiki can "evaluate" many alternatives rapidly once criteria for evaluation and methods of aggregating individual evaluation in various aspects are specified. In the man-machine context, man is the specifier of criteria and rules, which he can change as he makes different interpretations of previous results, and as he examines trade-off implications in the light of new findings.

- Immediate feedback and the ease of adjusting previous value assignments allow evaluations to be made serially and in context, as new insights are gained. Thus the traditional methods of having to decide in advance all the factors to be considered and all the conventions to be followed can be relaxed considerably. This will encourage man to explore many "what if" questions and trade-off implications. Man will be able to examine a much larger number of alternatives, weighing many different factors, than he normally can before a final decision or selection must be made.

- Kanshiki can provide a means of assessing and weighing different "points of view" or value orientations in group evaluation. Systematic methods, such as the Delphi technique, can be used for the direct involvement of experts and users in exploring possible consequences, priority issues, trade-offs, and even policy changes.

  Differing opinions and preferences are mostly due to differences in individual value orientations (and institutional or "public" values) and in degrees of understanding various aspects of a situation. Group interaction through Kanshiki can influence subsequent rounds of evaluation, not by group pressure, but by reasoning and increased understanding.

  Polarization may occur, but a completely even distribution (of the evaluators' value inputs) is not likely for most value-laden questions. Experiments have shown that individuals tend to be more responsive to value-oriented questions than to factual questions; that is, changes of opinion seem more readily attainable on value-oriented issues than on factual ones. Usually, no new values are introduced, but restructuring of values seems to take place in the light of new understanding about many sides of an issue.

- Qualitative or descriptive information in evaluation, intermixed with quantified information, will eventually be reduced to numbers using Kanshiki. However, using a conceptually "natural" method of eliciting a number (value assignment) from a person is as important as choosing appropriate aggregation rules for integrating these values.

  The "fuzzy-set" concept and associated techniques are used to provide explicit treatment of "matter-of-degree" judgments (e.g., "how safe," "how comfortable," and "how convenient"), and to provide relative judgmental situations (rather than forcing absolute judgments).

An Example of Evaluation

Many areas of application are possible and I can describe Kanshiki in completely general terms, but an example will be helpful in making the presentation clearer. Suppose a group of commissioners (evaluators) are evaluating a number of proposed plans for developing a park (local, state, or national). There are many criteria for determining the desirability of such plans, but for brevity let us say that "peaceful atmosphere" and "utility to the public" are the two most important ones. Since these are very general, such criteria are usually described in terms of component attributes such as "number of acres of vegetation or foliage," "number of feet or miles of streams," "variety of flowers," for the first one; and other attributes such as "number of picnic tables," "number of benches," "number and sizes of parking lots," for the second one. The latter group is relatively easy to evaluate for appropriateness since a set of desirable standards (per acre of park) is usually known. But the general criterion of "peaceful atmosphere" is much harder to represent since the total effect cannot be perceived readily from the components of the first group.

Scale models of proposed plans are often useful for visual overall evaluation, but it would be prohibitively expensive and time consuming to provide models for all the alternative designs, A_1, A_2, ... A_n, submitted (2).

One useful tool is a visual input/output display scope connected to a computer for man-machine interactive use (3).

Here, the terrain characteristics of the park-to-be area are displayed (preferably in color) to the group of evaluators and then a proposed design of the park is displayed with an option of enlarging any part of it for display (4). Some verbal descriptions and numerical information such as cost and those attributes mentioned earlier (number of picnic tables, variety of plants and flowers, etc.) can be added.

Each evaluator is now asked to give his opinion of the design A_1 in relation to the criterion, "peaceful atmosphere." This is expressed as "grade of membership" (in the set of all alternatives for which the criterion applies) in terms of a number in the interval [0, 1]. If the number is close to 1, say 0.94, then A_1 has a high grade of membership as far as this attribute is concerned; if it is close to 0, say 0.1, it is not a highly valued member. The question may be phrased in the following manner: "If 'peaceful atmosphere' is the only criterion with which to judge the proposed designs A_1, A_2, ... A_n, and if all the designs can be graded to take relative positions on a straight line between 0 and 1, where would you place the design A_1 compared to your highest ideal that would be at the position 1?"

Since comparability is important in qualitative judgment, other alternative designs from A_1, A_2, ... A_n can be displayed one or two at a time for comparison. Two or more A's can take on the same value in case of a tie. The evaluator can change his mind about the values he previously chose. The "grade of membership" he gives for the first design alternative he considers may be more or less arbitrary, but as he proceeds in the comparing process, the values tend to indicate the relative merits of the proposed designs.

All evaluators in the group make their evaluations independently of each other, so the set of values collected may differ greatly. Group interaction with or without anonymity and reevaluation of the set of values can be the subsequent step, using the on-line or off-line Delphi technique (5) (more about this will be discussed later), or the evaluators can proceed to another attribute, still independently of each other. The only thing they must agree on first is the initial set of attributes. These can be changed later, but the group must agree on the changes.

Fuzzy-set concept. I have tried to set a stage for an intuitive understanding of the "fuzzy-set" concept in the above discussion. Let us now clarify the notion of "grade of membership" mathematically. Suppose X is the set of all alternatives. Let A be a subset of X for which attribute α applies. In our park example, α may be "peaceful atmosphere." A person's subjective preference judgment can be represented by a preference relation which associates A_1 with a number in the interval [0, 1]. To this relation, I have assigned the symbol R. The value $R_\alpha(A_1)$ represents the "grade of membership" of A_1 in set A (see Figure 3).

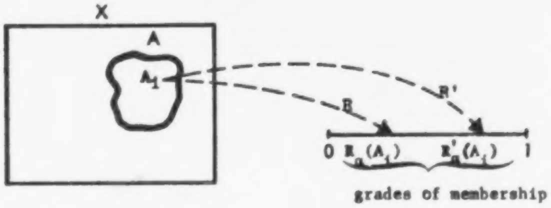


Figure 3. Fuzzy-Set Association

The two values R_α and R'_α show a possible difference in two persons' judgments about A_1 on its grade of membership for attribute α. This tends to make more visible subtle individual differences in value orientation.

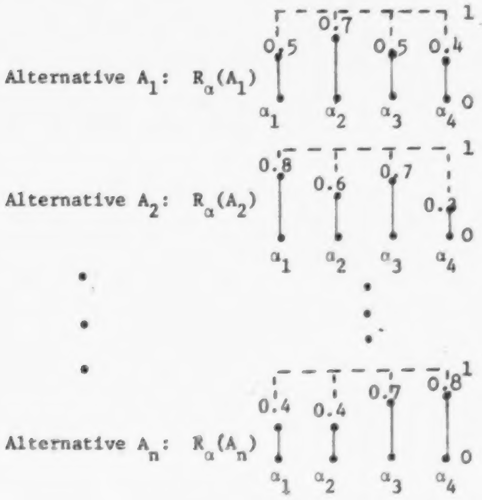
So far, we have been talking about types of attributes for which there is no sharp transition from membership to nonmembership. Of course, there are other attributes that can be defined in a non-fuzzy fashion, i.e., a "yes" or "no" answer (1 or 0 value) can be given; then its membership function becomes identical with the characteristic function of a non-fuzzy set.

Trade-off considerations. One of the most important benefits we get from the use of "grade of membership" is that trade-off concepts can now be dealt with quantitatively. Suppose in our example of the park design, "utility to the public" has also been graded for each alternative. One factor of utility to the public may be "accessibility to many parts of the park by car." But many people feel strongly that this requirement will be in conflict with "peaceful atmosphere." It is true, but exclusive concentration on "peaceful atmosphere" and little accessibility will deprive some segments of the public (e.g., those who are infirm) from enjoying the total facility. Then, trade-off implications must be explored. Questions such as "How much 'peaceful atmosphere' can be traded for how much 'public utility'?", which were meaningless in conventional evaluation, can now be treated sensibly because the two attributes are now comparable, represented by the same unit of measurement "grades of membership" (see Figure 4).

Even if all attributes were quantified (e.g., number of picnic tables, number of flowering plants, etc.), they are still incommensurable and the trade-off concept does not apply. It is, therefore, important to evaluate grades of membership for all the attributes, even though some attributes are naturally quantifiable, such as "cost of developing the park" and "cost of maintenance." Here, costs are still evaluated on a comparative basis.

The essence of this approach can be stated as follows: If it is inappropriate to quantify everything and reduce the measures to a single "measure of effectiveness" (e.g., dollars), then change everything into value-oriented judgment.

Figure 4 shows the comparability of alternatives and attributes (6).



α_1 = peaceful atmosphere

α_2 = utility to the public

α_3 = cost of development

α_4 = cost of maintenance

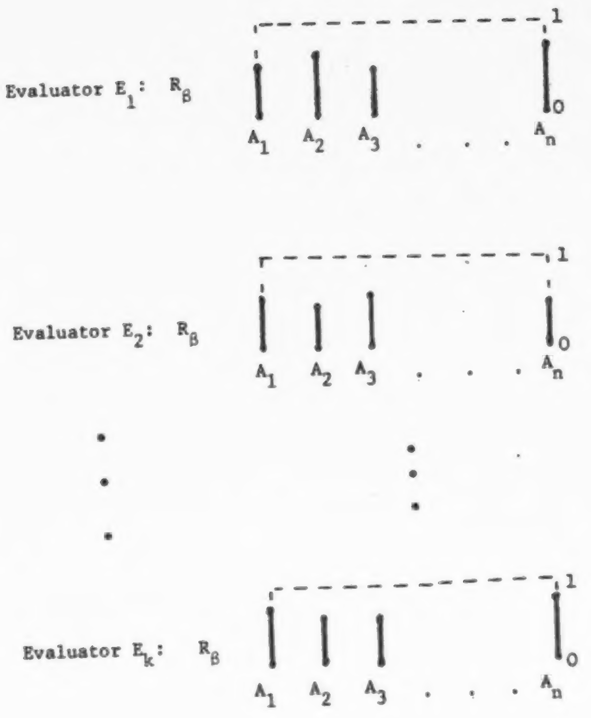
Figure 4. Trade-Off Comparison of Attributes and Alternatives

There can be interesting derivatives of this kind of exercise. As the evaluators made trade-off studies, new insights may be gained into the issues at hand and new ideas on design modifications or compromises may be proposed. The designer then may be consulted to check the feasibility and the cost of such changes. Or, the insight may be in the recognition that new attributes should be added, old ones deleted, expanded, subdivided, or several combined into one.

Even after all the attributes have been considered for all the alternatives, those values and vertical lines, though comparable, do not constitute the making of an overall judgment. One way to facilitate it is to calculate the summation $S_j = \sum_{i=1}^{m} w_i R_{\alpha_i}(A_j)$ of all the weighted "grade of membership" values over m attributes for each alternative A_j, where w_i is a weighting specification to indicate the relative contribution of α_i to the achievement of goals and objectives (ranking of attributes and assigning weights will be discussed later) (7). Calculation of the sum S_j and the weighted average, $\bar{S}_j = S_j / \sum_{i=1}^{m} w_i$ (called the summary value) for each A_j can be done by Kanshiki very rapidly. Now comparing summary values ($\bar{S}$'s) is a meaningful process since their values are again in the interval [0, 1], representing overall grades of membership.

Individual differences and group interaction. Since each evaluator will have his own set of summary values ($\bar{S}_j$'s), there may be collected diverse values of $\bar{S}_j$ for the group of evaluators. This divergence can come from differences in R_α values and/or w (weights) values. The Delphi technique or simpler group interaction may be used at this time. The Delphi technique may have been used earlier for both R_α and w values, but the evaluators are not likely to come to a complete agreement on one set of values (but eventually there will be fewer sets than the number of evaluators). Any group interaction may yield some influence toward agreement. Some studies on group planning seem to indicate that people may widely disagree on objectives and criteria but may readily agree to favor certain alternatives.

Let us see how different sets of $\bar{S}_j$'s for different evaluators can be compared. Let β represent a composite attribute of all α_i's that have been considered. In our park example, β will be "acceptability of a park design with all the features and weights properly taken into account." Summary values can now be used as $R_\beta(A_j)$'s and a display of R_β's for all alternatives A_1, A_2, ... A_n can be made for each evaluator (see Figure 5). The total display of all such values of all the evaluators may be shown in a scrambled order to maintain anonymity, if desired. In addition, a statistical group response, such as quartiles (Q_1, M (median), Q_3) of each $R_\beta(A_j)$ value, can be calculated. Seeing where his own evaluation stands within the group response may aid him in understanding the overall evaluation.



Evaluator E_1: R_β
1
0
A_1 A_2 A_3 . . . A_n
Evaluator E_2: R_β
1
0
A_1 A_2 A_3 . . . A_n
Evaluator E_k: R_β
1
0
A_1 A_2 A_3 . . . A_n

Figure 5. Overall Evaluation of Alternatives by Different Evaluators

As an evaluator studies the relative merits of alternatives and gains a deeper understanding of trade-off implications, his total conception of the situation may become more defined. If $R_{\beta(t)}$ is his preference function operating on the fuzzy-set at time t with respect to the global criterion imposed by β, then as t increases, $R_{\beta(t)}$ tends to converge toward a more precise function; i.e., the evaluator becomes better able to sort out alternatives.

Impreciseness of many decision-making situations is usually caused by a mixture of ignorance, randomness, and intrinsic fuzziness. This kind of exercise can help the evaluator to separate out types of impreciseness involved and learn to identify (a) where more information is needed (case of ignorance), (b) where probabilistic treatment is needed (randomness), and (c) where matter-of-degree judgments are needed (intrinsic fuzziness) that require increased awareness of other value systems besides his own.

In complex decision situations where many competing factors must be properly accounted for simultaneously, the interactive system can be made to keep track of the evaluator's tendencies. For example, suppose the evaluator is excessively cost oriented and his assignments of grades of membership for the cost attributes fall consistently outside the interquartile range (Q_1, Q_3) of the group response. The system can remind him of other important factors and trade-off considerations.

Interacting with other evaluators through the system and seeing where his own evaluation stands within the group response may influence him to take additional factors into account or to adjust his preference functions. If he feels strongly about his preferences, he can try to persuade others by stating the reason why the value should be lower (or higher) than the values (in the interquartile range) expressed by the 75 per cent majority.

The process of interaction and reevaluation can be repeated until, it is to be hoped, convergence is attained. Polarization may occur but completely even distribution is not likely for most value-laden questions. Individuals seem more responsive to value-oriented questions than to factual questions; that is, changes of opinion seem more readily attainable on value-oriented issues than on the factual ones, especially when relative impacts that certain factors make on the overall effects are realized by group discussion.

Steps of Machine-Aided Evaluation

The foregoing discussion in the park design example introduced only the fuzzy-set concept and the use of the Delphi technique. In this section, more nearly complete steps of machine-aided evaluation are described. It should be noted, however, many refinements that can be added through the use of utility theory, Bayes' theorem, simulation, sensitivity analysis, etc., are not covered here because of the obvious space limitation. Those concepts and techniques that are useful in the man-machine context are emphasized and others deliberately oversimplified.

There are seven evaluation steps to be followed, some of which will be elaborated on in the following pages. For simplicity, the procedure assumes a single user (evaluator) and group interaction is not emphasized. Steps are presented in the "usual" order but can be reordered at the user's direction.

1. List alternatives by name or number assigned to each.

2. List criteria for evaluation in terms of attributes.

3. Rank attributes and assign weights.

4. List values in their "natural" description (numerical or non-numeric) for each alternative's attributes.

5. Determine grades of membership of all values of attributes.

6. Calculate the summary value of each alternative.

7. Repeat any or all the steps above.

The list of alternatives and attributes may be prepared in advance covering steps 1, 2, and 4, and can be thought of as an attribute-alternative table (Figure 6). Unlike mathematical tables, this table can contain both numerical and non-numerical descriptions, even lengthy discussions supplemented by pictures that can be referenced. Therefore, the physical form of the information may not look like the table in Figure 6.

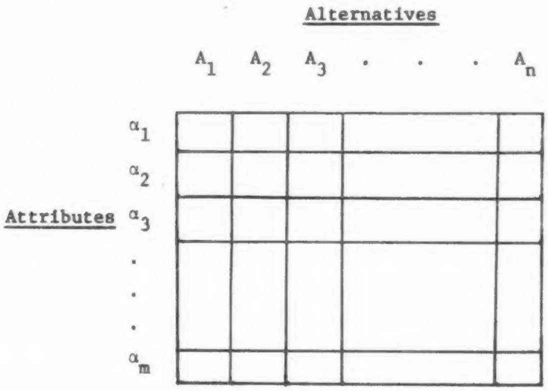


Figure 6. An Attribute-Alternative Table

In the following, expanded descriptions of the seven evaluation steps are given where necessary.

1. List alternatives by descriptive names or by distinct numbers assigned to them.

2. List criteria for evaluation in terms of attributes.

Attributes can be given on a noncommittal trial basis with full recognition that they are likely to be inadequate or incomplete; or they can be carefully selected by a group of people (e.g., policy makers, planners, experts, representatives of the public). Attributes may be separated into two groups, "desirable attributes" and "undesirable attributes", or they can be all mixed together. Subsequent instructions will reflect the choice.

At this stage, threshold values of certain attributes can be specified in terms of lowest and/or greatest values that are acceptable (e.g., the lowest acceptable load capacity and the highest acceptable cost for a vehicle). This allows some alternatives that do not meet the crucial requirements to be eliminated before proceeding with detailed evaluation. Threshold specification also aids the decision makers to distinguish between what are essential and what are desired.

3. Rank attributes and assign weights.

Attributes are rank ordered in terms of their relative importance in contributing to the objectives. If there are many attributes and ranking is difficult, Kanshiki can assist the evaluator by presenting only two attributes at a time. Judging the relative importance of two attributes is much easier than ranking the whole list. However, the resulting ordered list should be reexamined as a whole to guard against any possible context shifts, which may result when only two items are compared at a time.

If the evaluator's judgment of importance is transitive and total in ordering, the attributes are listed and displayed in the order of importance, possibly placing two or more in the same rank in case of a tie. The logic (computer programs) inside Kanshiki can easily check any inconsistency and ask the evaluator to compare again those attributes whose rankings are in conflict. If the inconsistency is not removed, it is likely that at least one attribute should be redefined to eliminate overlapping membership with other attributes. Other redefinitions often useful are substituting two or more other attributes in place of the current one and grouping some attributes together as one. An experienced evaluator usually can sense which ones are in need of adjustment (8).

When the ranking is complete, the attributes are displayed in rank order. The evaluator is now asked to assign weight (w_i) to each attribute, starting at the top-ranked one(s) with the weight of, say 100. Using this as the point of reference, the other attributes are also assigned weights. These weights should reflect the relative "strengths of effects" of attributes contributing to the objectives.

4. List attribute values in their "natural" description (numeric or non-numeric) for each alternative's attributes.

If some attribute values are originally given in verbose descriptions, they can be condensed to a few key words to be displayed along with the names of attributes. The original information sheets should also be available to the evaluator. Those quantified attributes, for which threshold values have been specified, will be consulted by Kanshiki at this stage for preliminary sifting out of alternatives.

5. Determine "grades of membership" of all the attribute values.

Using the fuzzy-set concept, each attribute value is judged in terms of "grade of membership"--i.e., a number in the interval [0, 1]. Since comparability is important in value judgment, other values of the same attribute from different alternatives can be shown one or two at a time for comparison. In Figure 6, this process corresponds to moving horizontally across the alternative on the same attribute line. When all the attribute values are judged in this way, a new table of values is created within the uniform scale. It will then look exactly like Figure 6 containing a single number (between 0 and 1) in each box in the table. When these values are displayed in bar graphs (see Figure 4), visual comparisons can be made easily and the evaluator, seeing the total picture of value assignments in terms of bar heights, may wish to change his earlier choice of values. A simple light-pen action on the display scope will lengthen or shorten a bar to his specification. Trade-off possibilities can be explored at this time.

6. Calculate the summary value of each alternative.

The summation $S_j = \sum_{i=1}^{m} w_i R_{\alpha_i}(A_j)$ and the summary value $\not{S}_j = S_j / \sum_{i=1}^{m} w_i$ are calculated for each alternative A_j as one of the basic machine aids, but some other forms of getting the summary value may be tried out. The evaluator can specify his own ideas easily with the man-machine communication language, User Adaptive Language (UAL) (see Hormann, et al, 1970).

If attributes have been separated into "desirable attributes" and "undesirable attributes," S_j is calculated using only those α's in the desirable category, and $S'_j = \sum_i w_i(1 - R_{\alpha_i}(A_j))$ is calculated using only those α's in the undesirable category. The difference in their summary values, $S_j/\Sigma w_i - S'_j/\Sigma w'_i$, where w_i's and w'_i's are weights attached to those attributes for S_j and S'_j respectively, may be called the "net-benefit value" for each alternative A_j. Comparing these values will result in a tentative conclusion concerning which alternative(s) is(are) best.

7. Repeat any or all the steps above.

The evaluator is encouraged to go back and examine his previous judgments. It is usually advisable, the first time around, to use first impressions in making attribute rankings and in making a judgment of grade of membership without too much deliberation. Stepping through the whole sequence rather quickly the first time, rather than dwelling on a single factor in detail, will give him a better understanding of how certain factors are accounted for in the total evaluation.

Iterating the evaluation process tends to bring many assumptions into the open, and the evaluator may become more aware of how the conclusions are related to the assumptions. For example, assumption on the objectives will influence the interpretation of objectives and criteria in terms of attributes and will also influence attribute ranking and weight assignments. Assumptions on political and technical constraints on the proposed designs will certainly influence many decisions. Probing into them with "what if" questions may separate out "real" constraints from imagined ones or those that can be overcome by negotiation or by creative problem solving.

The evaluator may, in the light of new insights and understanding, wish to redefine objectives and specify relevant attributes more carefully. Interacting with the other evaluators, or even with the policy makers, may bring further clarification. Possible use of the Delphi technique has been discussed; it can be used repeatedly in any of those steps described, but it will be most useful after step 6.

In studying complex trade-off implications that are typically nebulous, evaluators might gain a new perspective by asking Kanshiki to display an additional bar graph besides the one shown in Figure 4. Bars in Figure 4 can be rearranged to show the R_{α_i} values of different alternatives horizontally for each α_i (Figure 7).

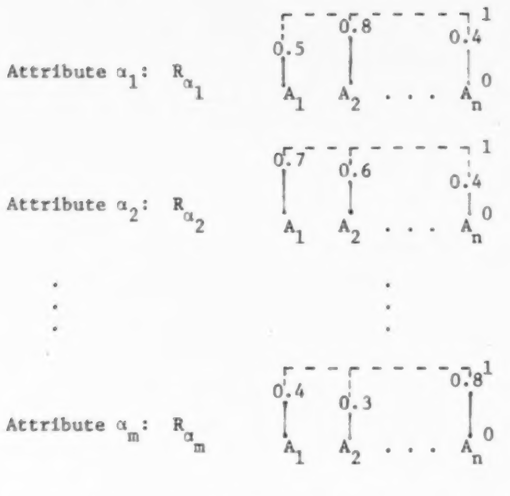


Figure 7. Rearranged Bar Graphs for Each Attribute

For group interaction using the Delphi technique, Kanshiki can provide another display, showing all the bar graphs generated by different evaluators for each attribute α_1 (similar to Figure 5 but for one α at a time, not for the overall β). The evaluators may ask "what if" questions on different value interpretations and trade-offs (either collectively or individually) that are not evident in the design alternatives; the answers may suggest a new or an improved design.

Potential Applications

There are a number of potential applications for Kanshiki, including evaluation of architectual designs and urban development plans. They are categorized in four groups in terms of their characteristics:

1. Complex equipment with many performance criteria.

Evaluation of different designs of complex equipment such as aircraft and underwater exploration vehicles can use machine-aided evaluation. In these, many attributes must be included in evaluation and they cover both factual information and subjective value information. This class of problems is less fuzzy not only because factual information tends to dominate but because the physical boundary in measuring operational behavior is relatively clear.

2. Selection of suitable locations for large complexes.

The problem of selecting a suitable location for a large complex, such as a model city development, often requires careful consideration of many attributes that are qualitative in nature. Among many possible locations, one or a few candidates are usually selected in order to proceed with designing, legal and financial negotiations, etc. Other examples of large undertakings whose location decisions tend to affect various segments of our society are: manufacturing plants, airports, hospitals, health-care centers, sanitoriums, rehabilitation centers, educational institutions, trade centers, highways, and transportation networks.

3. Complex combination of things that interact.

Making an appropriate EDP system selection from all possible combinations of available hardware/software products to meet the user needs is a complex problem. Guessing at a suitable hardware/software mix is hard enough, but evaluation of a wide number of configurations when the components interact usually requires an advanced modeling technique (Sutherland, 1971). Information on the performance characteristics of hardware and software components are separately available, but very little information can be had on the total performance characteristics for specific configurations--unless the pieces are all of the same manufacture. After modeling produces the system's performance characteristics, our technique can be used in total performance evaluation.

A similar situation facing the decision maker is the selection of alternative designs of hospitals, universities, housing complexes, or research laboratories.

Another area of interest is compensation programs to provide employees many different options. Companies who can provide many options will have a definite advantage in employee inducement and retention.

4. Long-range large scale programs comprised of many projects that are interrelated and interdependent.

Many government programs such as health care, welfare, education, foreign aid programs, and other research and development programs are in this category. This is an area of great importance because of its far-reaching effects, both intended and unintended. It is also the area of greatest difficulty because of its complexity, unclear boundary (sphere of effects are not clearly definable) and future-oriented consideration.

These programs or measures that tend to create many side effects or that produce long-term effects or irreversible conditions, must receive extra care in planning. Although the future is always uncertain and, therefore, no forecasting techniques can claim total accuracy, a variety of forecasting techniques combined with modeling can produce some indication of types of impacts a given program might make in the future.

After possible consequences of alternative courses of action are generated, the consequences can be arranged within a "decision-event map," indicating interrelation of actions taken, their intended results and possible side effects, and intervening events that are likely to happen.

Concentrating on the consequences in the timestream (rather than at one point in time), our technique, modified to include subjective probability estimates, can still be employed, using attributes that indicate future impacts (e.g., "rate of yearly increase in food production in country X, during 1970-1975, after introduction of farming equipment" or "number of farm workers in country X migrating yearly into cities during 1970-1975").

Admittedly, any future-oriented evaluation is very tenuous. However, evaluating proposed U.S. programs to assist underdeveloped countries is a more amenable problem than evaluating our own future possibilities. We can use the U.S. and other developed countries as models in planning to avoid possible undesirable consequences and to promote those attributes that are desired by the country. Although exact correspondence between the model and the real consequences in a given country cannot be expected, hindsight is readily available while foresight is not.

Summary

The importance of including many criteria of various types and degrees of imprecision has been discussed. The man-machine evaluation approach described here is our first attempt to tackle this task. Insight gained in using these techniques may lead to improvements or to new ideas and techniques.

Systematic analyses of the situation supplemented by intuitive judgment was emphasized. The following points may be worth reviewing:

- Consistency in treatment of all alternatives with many attributes describing desirability or undesirability. One aspect of consistency achieved here is the making of everything into a value-oriented judgment; even though attribute values may be objectively measurable, determining their worth in relations to the objectives requires a judgmental decision. The fuzzy-set concept allows explicit treatment of imprecise value judgments.

- Comparability. Since absolute judgment is far more difficult than relative judgment, the man-machine techniques facilitate the ease of comparison by bringing in other relevant factors in a visually comprehensive manner. In addition, the fuzzy-set treatment of attribute values make them commensurable, and complex trade-off possibilities can be explored much more readily than without such assistance.

- Systematic use of the knowledge and experience of experts as well as opinions of people from different backgrounds. Those techniques (such as the Delphi) for direct involvement of people can increase the acceptability of the evaluative decisions, if not the quality of evaluation.

Notes

1. This reliance permeates every aspect of the systems approach--in circumscribing the extent of the system; in deciding what hypotheses are likely to be fruitful; in making appropriate interpretation of policies, objectives, and constraints; in making assumptions about cause-and-effect relations and about information-gathering and processing requirements; and in putting facts together to develop a bigger picture by interpreting the results of information processing.

2. Techniques of making scale models, I am told, are being improved. They can be constructed much more quickly and less expensively than in the past. Also, there is a promising field of holography used in viewing three-dimensional structures that have been designed but that do not exist physically yet. Holographic plates are artificially synthesized from the given design and the known characteristics of interference patterns with respect to the structural characteristics.

3. See INTUVAL (Kamnitzer and Hoffman, 1970). This work concerns interactive design in urban planning, but the same facility and the technique can be extended to assist evaluators who may not be professional designers. It may be desirable to have a mixed group of specialist-designers, government officials, representatives of diverse civic groups, etc., to avoid personal biases as much as possible.

4. Ideally, each evaluator should be provided with an interactive facility. The evaluators work independently but can interact with each other through the system. To approach realism in evaluation, an existing park of similar size and purpose (if possible, one that nearly everyone likes) may be chosen. Photographs of this actual park and a display of how it looks in abstraction will facilitate understanding of how a proposed park will be expected to look.

5. See Dalkey (1969) and Helmer (1966). The technique was initially used for soliciting and collating experts' opinions in long-range forecasting, but many experiments have been conducted with members of the public for estimating desirability of certain programs, and understanding people's attitudes and value orientations. The major characteristics of the technique are anonymity, iteration and controlled feedback, and statistical group response.

6. In Figure 4, costs are shown in their grades of membership as the "preference" measure. Therefore, the lower cost, which is usually preferred, is rated high (the longer vertical line), and the higher cost is rated low (the shorter vertical line); this may be counter-intuitive. The evaluators may prefer to group together as "cost" all the attributes that should be minimized (e.g., pollution and noise) and as "benefits" all the attributes that should be maximized. Then these two groups are displayed separately (side-by-side but grouped together) and new values, $R'_\alpha = 1 - R_\alpha$, will be used for "cost" attributes (then a high cost shows a high vertical line).

7. This form of getting a single value for each alternative is not the only way. Some non-linear or nonuniform way may be used to account for different nature of attribute definitions.

8. Hierarchical structuring of attributes from general to specific is often useful in reducing inconsistant ranking, when many attributes are being considered in evaluation. Ranking is done within each level and recursive use of Kanshiki is possible for evaluation of each level separately, while automatically keeping track of other levels of evaluation and aggregation.

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ON EVALUATION OF MAN-COMPUTER PROBLEM WORKING SYSTEMS

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Abstract

Lack of adequate evaluation of over-all function in man-computer systems is seen as a remediable product of orientations of typical system builders. Suggestions are given for an approach which sees evaluation as best treated from a theoretical stance that views man-computer systems as communicating, changing information structures in which a problem is represented, distributed, and transformed.

The Machine Orientation and the Lack of Interaction Evaluation

People become interested in man-computer interaction systems via different routes. Typically, most become interested because they want very much to see a hard or tedious job of specific professional concern to them done more effectively. They tend to concentrate on the requirements of the chunks of the task which look most readily amenable to mechanization, leaving the human somehow to fill in the rest. Typically, they tend to concentrate on the hardware and non-biological software designed to implement the machine's part of the task. Of course, they do want the tool in the machine to be handy, and only minimally infuriating for use by someone strongly resembling themselves. Therefore, as they design and interact with the tool in the machine, they watch out for particularly annoying or clumsy things. That is, they patch up the snags the machine-based tool presents to themselves, the deeply involved, sophisticated user-builders.

The intellectual tool in the machine is then described in journals and conferences as a man-computer interactive system. But the human, interaction, and system aspects are not well described. Typically, little careful characterization of the processes in the man as he uses the machine to work a particular problem interactively has been developed. Often, as with the case of Negroponte's interesting Urban 5 system[1], it seems that many hours of potentially revealing interactions were used primarily to adjust the machine program, but not quite to document what could be learned of computer assisted problem solving. Typically, records of even a few of the interactions, from start of instruction about the nature of the problem and system to end, are not stored, or are not systematically examined. Ordinarily, little attention is paid to the changing shapes and loci of parts of the task, as work on it flows through information structures in the person, the machine, and through any other auxiliaries.

It is mostly in hearing anecdotes at conference coffee breaks that we learn that the designer-builder-users of man-computer tools feel that their minds--including their stocks of typical problem working processes, and higher-level ways of organizing them--are changing. The anecdotal accounts are enough to pique curiosity, but not enough to constitute the empirical basis for a theory of man-computer interactions in problem-oriented work.

Such a collection of empirical knowledge and such a theory based upon it might help in making new man-computer systems to help do hard jobs better. And better empirical knowledge of the systems--person-in-interaction with task and tools--might make possible more cogent evaluation of the claims made for the systems and the skeptical replies those claims stimulate.

The potential advantages of this kind of knowledge are widely sensed. But the people who have become interested in man-computer interaction systems through the route of building their machine parts in order to get hard jobs done usually do not seem impelled systematically to evaluate the interactions themselves. Partly, this is because in the education of most scientists and professionals, the emphasis has been much more on getting a final product, construed as an entity existing outside oneself, and describable in the language of static, achieved thinghood. The educational years and the broader cultural context have not helped them to look carefully at how persons work their ways through hard problem working processes.

A successful human problem worker will actually have not one but two products of his effort--one dynamic, one static. He will have had to compose both a dynamic "solution"--an effective procedure for solving the problem--and a static thing solution, resulting from application of the procedure to the problem.

Typically, the business of composing that effective problem working process is described only in the vague terminology of inspiration and perspiration. Then it gets left behind, unexamined, or poorly characterized and stored, and hence rendered ephemeral. The hard, static, thing solution product, in contrast, is lovingly recorded and shown about.

The grant and contract structure which supports man-computer system design for solving hard problems shares in the larger culture's bias toward static thing products (rather than toward those solutions plus accounts of dynamic solutions) as sufficient evidence of the system designer's accomplishment. The machine-based part of the system and a short, unspecific account of how the static end solution resulted when the machine was paired with its designer's friends may not be all the contractors really needed to ensure getting a useful tool. But it may be all they asked for.

The tool in the machine at that point may be psychologically relatively awkward and inaccessible to those people in the field for whom it was designed. In our culture it tends to be assumed simply that, if a tool has merit, its use will diffuse somehow. If it fails to diffuse and is eventually dismantled or consigned to the dustier archives, that eventually will be taken as presumptive evidence of its intrinsic lack of worth. But diffusion may have been impeded and demise speeded by the lack of genuine articulation of the procedures necessary to the soft and interactive parts of the system. There might actually have been high intrinsic worth in the tool in the system, but substantially none of the process specification or guidance necessary to make it function successfully as a component of a transportable interaction system for use with people.

Sketched, and perhaps caricatured so far has been a machine-and-static-end-product orientation to man-computer system design. It can be contrasted with a person- and interactive-problem-working-process orientation to building and using man-computer systems. The second orientation is now seemingly common to just a few system builders, and to a group of people who are becoming interested in man-computer systems via a different route.

The Interactive, Process Orientation

People becoming interested in man-computer systems because of an interest in information processing psychology or in describing as well as assisting the design process may be more likely than most members of the group of tool designers to have the second orientation. Their interest may have several related roots. First, they have looked to computer science for metaphors and organizing constructs useful in thinking about any complex, information handling creature. Second, their curiosity about psychological events occurring in work on complex problems impelled a search for ways of recording accurately the many details of such a process. When a person interacts intimately with a computer-based problem working assist, the traces of his interaction can be preserved. They can be used in conjunction with think-aloud protocol analysis, interviews and other methods to externalize process events. Third, curiosity about what people can do without a computer--equipped as they may be with their own subsets of the conceptual tools provided unevenly by the culture--extends quite naturally to curiosity about what people will become with a family of new and extremely powerful assists to cognition.

New Collaboration Opportunities

As things stand presently, the (still few but growing numbers of) workers who became interested in man-computer interaction via the second route are not always in a position to build the machine systems to study work on really complex problems particular to professional fields. And those who came to interest in man-computer systems via the first, machine-building route often are not ready seriously to study the information processing events occurring outside and in relation to the machine. With some notable exceptions[2] the groups are still too far separated, and usually do not know where to find each other. It seems that the design, description, evaluation and diffusion of man-computer systems as systems could be greatly improved by their collaboration. Perhaps the new trend on campuses to have faculty with primary interests in mental function work closely with architects and planners is starting to provide an institutional basis for that collaboration. Currently, the main collaborations between those two sorts of professionals center on such topics as perception and evaluation of the physical environment. Here we note that the study of complex problem solving in design and planning, using man-computer interaction, offers another important opportunity for investigators with complementary skills to make something new and valuable. They have a chance to expand basic knowledge of assisted higher mental function and, at the same time, develop a sounder basis for evaluation of particular new interaction systems. Assuming some people are now newly roused to the call, let us look at what a few considerations leading to a framework for evaluation of man-computer systems look like.

Toward Evaluation of Man-Computer Interaction Systems

First, a brief indication of the breadth of concerns; then, a move toward their focus. All aspects of the given task or problem, the human problem worker, the interfaces, the computer and its programs, and other auxiliaries which can possibly affect the nature of the final static problem solutions or the way of finding procedures to get them will be potentially relevant to the evaluation. For example, consider such a simple thing as the machine's propensity for breaking down. We know that strategies may have to be invented to protect a long and difficult problem-working sequence from machine failure wipe-outs, both for the sake of the problem solver and for the researcher who would study his processes. Thus, the reliability question may push toward modularization of a problem working process. The increased motivation of the person's search for and periodic review and protected storage of results of work on subproblems might be expected substantially to change his style of work (cf. the watchmakers in Simon[3]).

For another simple example: the clatter, glare, whoosh and interruptions of computer rooms may add to a problem worker's difficulties in attention allocation and place-keeping as he reacts to a display. A push toward note-taking (especially in the absence of a hard copy device) or increased disorganization in the problem working record are likely to result. A good evaluation of a man-machine system should have access to a comfortable, quiet private room or booth from which the computer can be accessed.

Rather than dwell on them here, I suggest strongly that a check list of often relatively obvious, but often relatively overlooked aspects of the working situation should be developed for any system to be evaluated; its items should be examined for their effects on the interaction, and included in the description which will eventually be made of the man-computer system.

Evaluation with Respect to Purpose and People

Careful evaluation in terms of the definition of the purpose of the system, including description of the sorts of persons whose participation in it is expected,again seems almost too obvious to mention. Yet, it is well known that computer tools often are designed as very general assists when a more special purpose tool would do better on actual real-life tasks. And it is known that, in contrast, very narrowly specialized tools often are built to handle just a tiny component of a large problem working process, but they may do it in such a peculiar fashion that they constrain the whole large process to deal with an uncomfortable representation or approach. The relation between intended purpose and actual function may be seen to have become tenuous when both are re-examined at evaluation time.

The description of those who will be human participants in the man-computer system must indeed be part of the definition of purpose. If the person in "man-computer" is to be the "typical office architect," then the new tool should be tested with fair examplars--not with computerniks or any of the other sorts euphemistically referred to as "casual subjects." Computer tool builders (and most other people) seriously underestimate the differences in ways that people of diverse backgrounds may approach a problem of any difficulty or complexity, if left to their own devices. The kinds of documentation, error messages, tutorial capabilities in the machine, and educational procedures necessary effectively to introduce the tool may be considerably different from the tool builder's anticipations based on introspection and friends' accounts alone. Careful use of the tool by different groups of subjects can sharply increase the builder's sensitivity to those parts of people's problem working processes that are dissimilar, and that vary greatly in quality and need for guidance. The person who must learn to become part of the system without the fond system builder at his elbow hinting at what has been left inexplicit is entitled to have access to an evaluation account which is likely to be realistic for him.

In general, the wider the educational, cultural, and age ranges of the individuals who are likely to be using the machine-based tool, (a) the more care is needed to make explicit for the minds of some what can be left implicit for the minds of others; and (b) the more the evaluation must take the adequacy of materials explicating use of the tool into account.

Need for Characterizing Least Understood Processes

One paradox has been noted already: the builders of interactive man-computer systems tend to neglect study of actual interaction and of the events occurring in the person when their systems are used. Here is another: the portions of the problem work that are left to the person in an interactive system are characteristically those for which the detailed requirements for an effective approach to solution are least clearly understood. One can envisage the two as contributing to a funny trend: the more a part of a problem working procedure is clearly understood,the more likely it is to be mechanized. In turn, the more what a person knows clearly gets mechanized, the more his function as the person part of a man-computer system is left to concentrate on the relatively fuzzy, unclear parts of things he knows how to do. After several cycles of this sort, the person in the man-computer system might be using on a full-time basis just his most inscrutable functions--those things he knows least well how to describe, to perfect, and to teach! It would be good if, in the time freed from doing the mechanizable tasks, he should be able to generate new ideas for study and characterization of those parts of what he does that he still cannot understand. It is impractical to study as yet unmechanized human performance only or even primarily with the aim of computerizing it. We shall always want to know more about the unmechanized parts of what we do because (a) there we shall be at the frontiers of our knowledge of ourselves and of the world we model (cf. Minsky[4]); and (b) because it is those processes that will have to interface with and to make effective use of those knowledge processes which will have become mechanized at any given time.

Mechanization of component parts of a large and complex problem solution process establishes a series of interface problems. The inputs to and outputs from each mechanized phase of the problem-oriented work has to be translated or meshed with the next human--or computer, or mixed man-computer--phase if they are to contribute to a solution process which is coordinated over all. Unless the conjoint man-computer system's knowledge of organizing, coordinating, interfacing, and intertranslating the results of part processes is highly developed, the little mechanized bits may just float--the elegance within their structures contrasting strongly with the confusion and imprecision about how to weld them together. The functions at interfaces between problem working subprocesses and the over all integrative functions extending through the entire interactive process offer critical points for observation.

Perhaps the reader, noting the work accumulating for an evaluator of a man-machine interaction system, is beginning to protest. Perhaps by now he is ready to support just designing a tool, calling it part of an interaction system, and letting it make its way in the world on its own! Let us back up a bit for a historical view of the issues before moving into some more explicit suggestions for overworking the evaluator.

Machine Obsolescence and the Human Factors Claim Stake

Why is it that conversational man-computer systems are usually presented more as demonstrations of the programming in the computer than as research on building and verifying assists to complex human functions? Recently, Carbonell[5] and Nickerson[6] addressed this question. First, a frequently offered explanation was: state-of-the-art computer systems are changing so fast that careful research on any one of them is too likely to be out of date in no time. Second, Nickerson noted that the human factors branch of psychology--the workers who specialize in studying such things as the design of airplane cockpits in relation to pilots' capacities to monitor vigilantly, to be alerted to danger signals, etc.--had made an early and vigorous claim that the man-computer interface was to be their domain of study. However, relatively little has come in the wake of this staking out of territory. This may be because the human factors approach focused more on the study of attention, perception, and physical interactions with task environments than on the study of complex information processing. The man-computer interface does indeed include room for some of the traditional human factors concerns in consideration of terminal design, etc. But the sharing of an elaborated problem working process between man and computer does not fit the old man-using-cockpit machinery types of research paradigms.

Carbonell has pointed out correctly that, as the computer parts of man-computer systems change rapidly, the human parts are likely to remain the more nearly constant, and the more nearly worthy to be the focus of intensive study. Thus, it may be possible to do dual-purpose research: families of studies which examine events in a current man-computer system both to learn new generalizations about human function in working interesting problems and to evaluate a state-of-the-art tool in the machine as it functions when paired with a man. In any single study on a particular system it may be very hard to disentangle which parts of the effects found are due to hardware and non-biological software peculiarities. Needed, then, is a body of related studies which would describe--carefully and in at least partly comparable terms, using comparable problems--the events characteristically occurring in a variety of man-computer systems of different design. Perhaps with the development of a nationwide computer network joining major research centers--the ARPA (Advanced Research Projects Agency, Department of Defense) network--it will be practical for an investigator at a single center to start genuinely comparative study of man-computer systems. His subjects could conceivably have access from one place to expensive, machine-based special problem working tools from over the country. Such a body of work would use the data generated in problem working activity to supplement existing knowledge of higher mental functions. That newly supplemented knowledge could be used, in turn, (a) to diagnose places in which limitations on and vulnerabilities of human functions would be expected to act as bottlenecks to the function of the conjoint system; and (b) to suggest ways of getting around the bottlenecks.

The works of Carbonell, of Hormann[7] and of Hormann, Kaufman-Diamond and Martín Cinto[8] all suggest why a traditional human factors approach to the problems we have been discussing would have been insufficient. Those authors indicate in different ways that the man-computer system must be studied as a system of active processes among information structures. The system thus would best be representable in the language of data and control, program and procedure in the man and in the auxilary components of the system.

The Start of a Conjoint Information Structures Approach

It would be nice now to be able to point to a clearly worked-out framework for thinking of interacting information structures in problem solving, ready for use in the evaluation of man-computer systems. Instead, I shall indicate something of what it might look like.

To get a first level question quickly out of the way: of course basic computer science will have to treat the claims of any system. If it is claimed that the machine part can perform certain computations and output them in a given time, verification of that claim must be undertaken before we can go on to any higher level interaction analysis with safety.

The main appropriate level of discourse for a man-computer system evaluation is the level of a theory of problem working activity. "Problem working" because solutions are not always to be found, and "activity" because we want a theory of actions, and not just of outputs. We can think of descriptions on which theory is to be based as ideally spanning the course of events from the time a person (or team) first begins active thought about a problem, to the time when he either abandons work permanently, or for an indeterminate long time, or solves the problem.

The theory should be capable of taking as data accounts of events in the head of the human worker, and accounts of auxiliary computing events which the human sets into motion in the environment--including such things as data seeking by research assistants, displaying, calculating, etc., and involving such resources as libraries, films, lab tests, conferences, and computers. For building theory, an account should state not just that information was called for, but something of how need for it was noted, how it was gained, how it was used (or not), and how its use or abandonment affected the larger, ongoing problem working process. To say it more subtly, we want to know what happens to data the information processor seeks and at first attempts to use, then perhaps seems to overlook, or to be unable to incorporate into his solution process. Have those data been stored on note cards, or in a diagram on paper, or in long term memory, or in some substructure of the computer and become inaccessible? Has it been impossible for the person in the system to maintain a working awareness of the many parts of the problem and the many items of potentially relevant data as he starts to work his way through a procedure?

We want to be able to ask, to what degree could different ways of conserving the load on the human's very limited short term memory[9] or, better, immediate processor capability[10], and of increasing the transparency of structure of the conjoint problem working system's data and procedures be of help to the person, and hence to the functioning of the system as a whole? It will be when we can use many questions like those to query the detailed data from a man-computer system's run that we shall be capable of the kinds of system evaluation that will feed back to both better education of humans and to better-designed computer assistants to humans.

Aspects of Representation in Man-Computer Systems Evaluation

Let us go on with suggestions of what should go into a theory of problem working activity usable, inter alia, as a basis for man-computer system evaluation.

A simple way to introduce the notion of representation if it is unfamiliar is to suggest that the reader quickly give the answer to the following two questions: what is the fifteenth letter of the alphabet? what is the state lying on the western boundary of New Jersey? Likely, the answer to the first was obtained by counting down an internally recited list of alphabet letters, and the answer to the second by imagining a rough map. The reader working in those likeliest ways can be said to have used list and map types of representations internally to work the problems posed by the questions.

Issues of representation quickly become more complex when we talk of problems which must be dealt with by several, or many, information processing substructures, which may have or require different representations, and which must, in addition, represent many nested levels of organization in a problem working process. Many of the problems posed by the critical issue of representation are well treated elsewhere.[11] Representational issues especially pertinent to a theory of man-computer interaction include the following:

(1) An old chestnut--for any problem or subproblem, does the representation available in the person (of a given educational level) have any easy correspondence or mapping to a representation in the computer? How much forcing of the human's way of representing the problem is necessary or desirable in order for him to interact with the computer? How much is using an enforced representation likely to give him new insights, or a dividend of knowledge transferable to other tasks? (We are accustomed to consider this issue primarily from the point of view of unnaturalness or inconvenience to the human in the system; it is good also to note that a strong motivation to work the computer can help motivate people to learn broadly useful representational and inferential skills that they may lack.)

(2) Does the way the representation and distribution of data occur in the person and his auxiliaries, including notes, diagrams, computer, etc., permit easy extraction of meaning from within each, and easy comparison and recombination of meaning extracted from each? Note that the answer to this will depend very much on the information extracting and comparing skills of the human user, which may be specifiable in part and not only on the way the computer program was built. An evaluation should suggest places for specific training of human complex problem solvers in information handling skills that are revealed to be problematical for them in the context of a system they want to use better.

(3)How do(a) the process of building the representation and(b) the locus of representation of data and control programs in the system made of the human and his auxiliaries affect desired outcomes of the interaction? Does the human see so much of the task as "turned over" to the computer that he fails to elaborate his own mental structures for working most effectively with the problem's parts and with its over-all organization?

In the absence of good prompts, there is a tendency for some people to react minimally to what already exists in a machine, functioning more nearly like mechanical switches themselves. Having turned on a process in the computer, they may do very little to build within themselves elaborated ways of using the computer's outputs to solve the problem better, or to model and extract the features of the entire course of working the problem in their heads for future use.

It is probably true that our intellects are largely constructed by ourselves out of the procedures we have made in building our own programs to solve problems.[12] If so, then the ways some persons function in man-computer systems to bypass constructing their own internal programs could have a stunting, rather than a growth-promoting effect (compare reference 8). The person in the man-computer system potentially has the opportunity to learn more about problem working organization in an active and concrete system, and to learn more about his own heuristic processes and modes of assisting them. But whether he will take that opportunity, or will move in the reverse direction, failing to build his own personal structures, is not certain. It will depend on how well the prompts, instructions, transparency, etc. of the system help and stimulate his abilities for heuristic representation-making. Helping people to represent the organization of a complex process shared between themselves and auxiliaries is necessary, since people generally are not good at that.

The state of the art in representing the organization of complex, super-mindlike structures in problem solving is exemplified in work on the DENDRAL program[13] for assigning chemical structures to mass spectrographic data. Useful ideas for conceptualizing man-computer interaction can be gained from accounts of this large, wholly machine-based system whose methods and knowledge have been checked with expert chemists. Its several generalist and specialist subprograms must interact and communicate with each other as consultants and assistants at different times in work on a problem, making it resemble the division of complex functions according to ability seen in man-computer systems.

Judgment-Requiring Problems and the Susceptibility to Existing Structure

Another way to consider the possible effects of existing information structure in the machine component of an interactive system emphasizes the nature of the problem to be treated. For tasks that humans know how to do nearly algorithmically, the likelihood of significant distortion of their solution processes by details of the work situation and of structure in the assist system is low. But in looking for possible effects of machine actions which impose structure on an evolving, interactive process during work on a many-staged problem that is not well understood, it pays to remember the great susceptibility of judgment processes to distortion. It is usually just such complex,"unalgorithmized," poorly understood, solution-evolving, judgment-requiring tasks that are thought suitable for man-computer interaction (instead of total mechanization). As I have mentioned elsewhere[8], the more that judgment and weighing and balancing of complex factors are necessary in doing a task, the more susceptible the human's procedures and the task outcomes seem to be to subtle factors of personality and attitude, and to subtle features of the assist system, including arbitrary details of its design. Therefore, it is important that the person in the system, and the evaluator of it be able to describe and to estimate those influences on the person's way of working a judgment-requiring problem that come from ways in which building and maintaining parts of the problem representation are handled in the system.

Sequences of States in Problem-Oriented Work

In order for detailed, process-critiquing evaluation of a man-computer system to be possible, it is important to know the status of the problem-oriented work at many different moments during formation of a procedure for solving, and (if they are separate) of executing that procedure to make a static final solution product. Any complex problem passing through a man-computer system will undergo transformations as parts of the system act on it; and the parts of the system themselves will have to change states as they develop heuristics and unfold old and new program structures to deal with parts of the problem. Because a theory of problem working is a theory of successive, related, goal-directed *actions*, it must be built on reconstructed accounts of actions. A theory which can be used as a basis for evaluation of the problem solving functions of man-computer systems should be built at least partly upon cross-sectional, or "snapshot" representations of the status of the problem, as it is represented and distributed in the entire, conjoint problem working system at critical moments during the work. The snapshots should include statements not only about the problem itself, but about the structures encountered at those moments in the information processors themselves. To develop such a snapsnot analysis for a man-computer system interactively working a hard problem is a difficult task. It can be at best only roughly approximated--but perhaps usefully so.

For a complex program which uses many subprograms to work a problem wholly *within* a (specifiable) *machine*, a description of the successive states of the relevant subprograms-cum-problem parts is more readily conceived. Carl Hewitt[14] has been working with the "snapshot" technique as part of a way of building theory about the natural history of a problem in a complex problem solving system--namely, his PLANNER, which is wholly machine-based.[15] I have tried to use something like this approach to describe the natural history of a problem in a problem working system composed of a person and his auxiliaries, including written notes and computer. Because of the difficulties in getting extensive reports on the course of action within the person without changing it, the notion of successive snapshots of the status of the problem distributed over the man-computer system still functions more as a metaphor or an ideal (cf. the case of KN in reference 8).

Things to Come

The written portion of this presentation has sketched an attitude toward the evaluation of man-computer interaction systems. It has suggested a little of what a descriptive empirical basis for building theory, and a theory of problem working activity which would support cogent system evaluation might look like. The oral conference presentation will include concrete examples illustrating points in the text about representation, and about states, snapshots, and natural histories of problem working events distributed in interactive systems. Special problems of understanding and evaluating machine assists to synthetic and constructive aspects of work in design will be considered. Interesting features of existing man-computer systems in design (e.g. that of Johnson and colleagues[16])--including the apparent psychological assumptions made, and things to be learned from careful evaluation of them in use--will be discussed.

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IMPROVING DESIGN DECISIONS: RECOMMENDATIONS FOR A COMPUTER SYSTEM FOR USE BY THE BRITISH GOVERNMENT

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1: Setting System Requirements

An architect's primary task is to find ways of making the environment meet the needs of its users. For this, he handles, invents forms and spaces. He deals with a very complex set of relationships--relating maintenance and construction problems to the elements to be built, and these to the activities of the users and their objectives. In doing so, he is weighing the 'costs' of what is to be supplied against the 'benefits; of meeting the users demands. To do this better, he must constantly be learning more about these relationships. Yet at present, most of these relationships are handled intuitively and the lessons learned by one designer are rarely transmitted to the next. The main objective of this study is to aid designers by helping them to improve their ability to make better decisions when handling forms and to use the means for doing this as device for transmitting new insights.

Our first objective was to define what designers do in order to articulate what we wished them to improve. This we did by studying the history of a development of a British government office building. From this, we selected a sample area of the designer's investigations to study in detail. We concentrated our attention on the cost issues raised in the design process, particularly capital cost issues that the designers considered after the budget was set and before detail studies were done. We then analysed the questions raised and from this developed a general notion of what activities are characteristic of the design process.

Our second objective was to develop a set of computer based operations to aid this process. Hence, we set up a scenario of how a computer system might aid one small, but typical, step.

We found that costs could not be handled separately from the context of other concerns - and hence, have attempted to describe the larger context needed. The designer, when he went through his basic operation of adjusting the environment to the problems of its users had to consider a wide range of complexly related elements, especially if he was to make a decision by relating the costs to the benefits they would bring. We sketched out very roughly this complex skein of elements - relating the elements of the environment to the objectives of its users and the activities by which they are met, and relating in turn these environmental elements to the costs of constructing and maintaining them.

Our third objective then became that of making recommendations for a computer system that was based on this larger context. We were particularly concerned in describing it to preserve and enhance the value of the designer - his desire to learn further about problems and form, and his ability to exercise consequent insights. Because we wished to take these values into account, the system we have described is meant not only to aid him in making decisions, but to aid him articulate his design operations, transmit them to other designers, and improve them.

Our final aim was to outline a strategy for the development of the system. Because users of the system are meant to understand its operations and improve them, we have proposed that the system initially be developed only in a rudimentary way in that it will continue always to be further extended and developed through use. (This part of the original report has been deleted)

1.2 Design History, Cost Questions, History Model

To find out what information design teams need to have available we decided to look at what designers do and should do in their work. For this purpose we chose as an example the design of a small office building at Penrith which was carried out by MPBW during 1969. This single case study was a reasonably typical design process. In particular, we tried to establish what kind of information the designers of the Penrith building would have needed to make better cost decisions. For this purpose we have tried to analyse the kinds of questions which designers do ask (and might ask) if they were not inhibited by the present unanswerability of many of them.

Cost Questions

For analysis we compiled (Figure 1) a list of questions, derived from the Penrith case study. The questions which might legitimiately be raised to evaluate design proposals are inexhaustible: we chose to concentrate on questions having a bearing on cost. The costs of providing a suitable environment are incurred through construction (capital costs), through operation (costs-in-use), and through the carrying out of activities in buildings to achieve desired goals (costs for benefits). Although we listed questions affecting costs-in-use and cost for benefits, we chose for simplicity to analyse only capital costs. This list could never be complete; there is no theoretical limit to the questions that might be asked nor any 'right' questions. Even when all the questions are thought to be stated more questions could be

RELATIONSHIP OF QUESTIONS TO MAGNITUDE OF DESIGN CHANGE

DESIGNERS QUESTIONS (in chronological order)	MAGNITUDE OF DESIGN CHANGE: Very Large (Whole Design)	Large (Major Design Change)	Medium (Small Design Change)	Small (Constructional Detail)
1. What is the cost limit?	*			
2. What is the cost of standard building?	*			
3. What number of storeys in cheapest?		*		
4. What is the cost of a chamfered corner?			*	
5. What would a 'landscaped' office cost?			*	
6. What is the cost of an oblique angle?			*	
7. What do tunnels for car access cost?			*	
8. How much are 2 stairs versus 3 stairs?			*	
9. Are projected stairs cheaper?			*	
10. Is the proposed space allocation cheapest?			*	
11. What is the cost of street edge parking?		*		
12. What do different parking solutions cost?		*		
13. Cost of the Highways department rule?		*		
14. How much does it cost to omit 2 departments?	*			
15. What is the cost of the 3 pavilion scheme?	*			
16. How could its cost be reduced?			*	
17. What is the cost of the parallel block scheme?	*			
18. How much does the ring corridor cost?		*		
19. Is it cheaper to put the stair in centre?			*	
20. Is "flying" corridor scheme cheaper?		*		
21. What is the cost of condensing ring corridor?		*		
22. How much will the cladding cost?				*
23. What is the cost of a square building?	*			
24. How much does separation of public cost?			*	

Figure 1

QUESTION ANALYSIS

added, even if only details of those asked. Also, the questions conceived are generally limited to those that it was known could be answered. We claim that this list is typical, because it is comprised of the actual questions 2 sets of designers asked (the original designers and then ourselves) and is valid for our investigation because answers to any of the questions could lead to cost effective design changes.

Question Analysis

Although the set of questions is hypothetical, an analysis of it throws light on the operations which designers perform and provides criteria which a computer system to aid designers must meet. The upper margin of Figure 1 is a spectrum ranking cost questions in terms of whether they are concerned with the overall form of the building (affecting most of its performance) or whether they deal only with some sub-elements, some details. The pattern illustrates in a general way how a designer proceeds.

Note that there are several overall questions (questions 1,2,14,15,17,23). These generally arose just after the designer came up with a major form departure (questions 2,15,17,23). It seems that at the outset, the designer would propose a new form, then he would study it and propose a new form based on what he had learned. After doing this several times, the designer proposed rapidly a succession of new forms (questions 15,17,&23) without asking detailed questions. It is our inference that he used the first forms as foils against which to study the elements of the design problem, then, upon learning about those, started making new forms more quickly. At the end of the sequence of new forms, he settled on one and tried to perfect it, asking detailed questions. Then he rejected that, but used the insights he gained to design the last scheme (question 23). After this we assume he never asked overall questions again because this was the scheme that he took into production drawings.

History Model

The pattern that emerges is clear...the designer proposes forms, investigates aspects of his problem, and goes back and forth modifying his notion of form and solution and problem depending on what he learns in the process. The designer wants to understand all problem elements before he makes a final design; he wants to relate these elements to his particular project solutions; and he goes back and

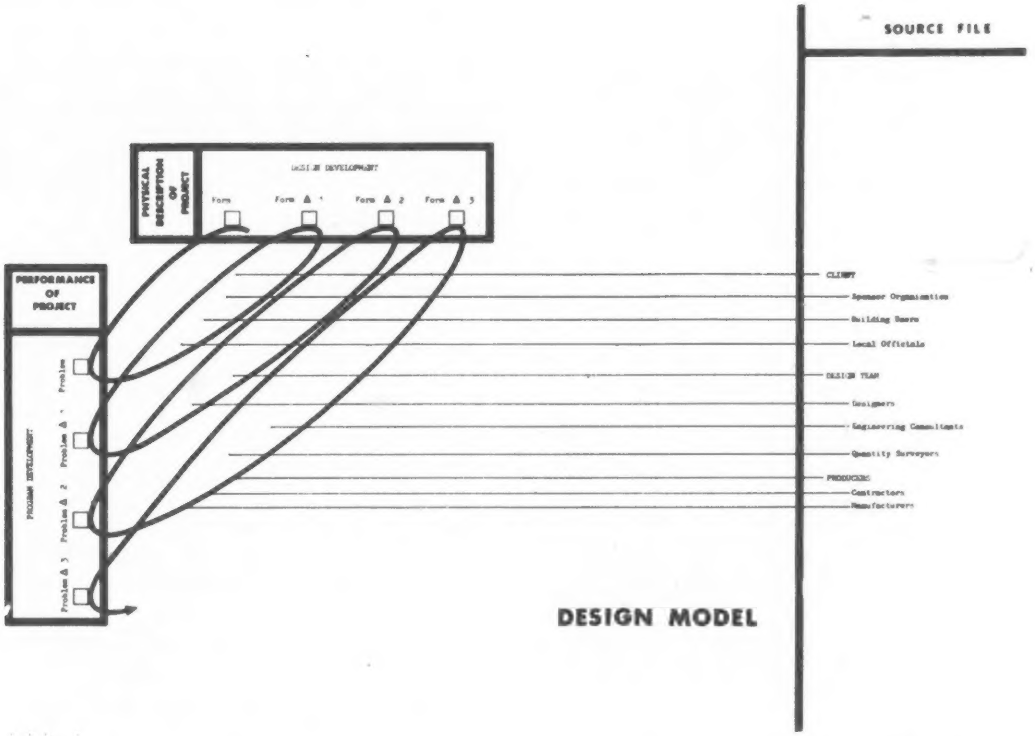

SOURCE FILE
PHYSICAL DESCRIPTION OF PROJECT
DESIGN DEVELOPMENT
Form
Form △ 1
Form △ 2
Form △ 3
PERFORMANCE OF PROJECT
PROGRAM DEVELOPMENT
Problem
Problem △ 1
Problem △ 2
Problem △ 3
CLIENT
Sponsor Organization
Building Users
Local Officials
DESIGN TEAM
Designers
Engineering Consultants
Quantity Surveyors
PRODUCERS
Contractors
Manufacturers
DESIGN MODEL

Figure 2

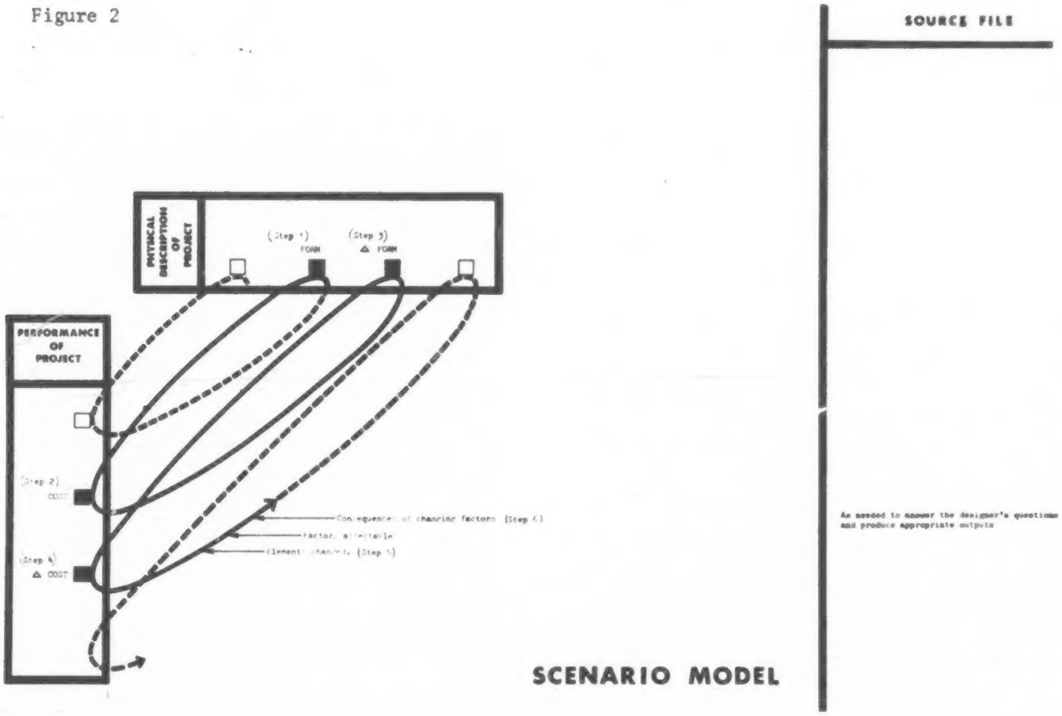

SOURCE FILE
PHYSICAL DESCRIPTION OF PROJECT
(Step 1)
FORM
(Step 3)
△ FORM
PERFORMANCE OF PROJECT
(Step 2)
COST
(Step 4)
△ COST
Consequences of changing factors (Step 6)
Factors affectable
Elements changed (Step 5)
As needed to answer the designer's questions and produce appropriate outputs
SCENARIO MODEL

Figure 3

forth between form and problem modifying both, learning as he makes his changes.

This process is shown in Figure 2 where the route the designer takes is described as a widening spiral as he iterates between problem and physical solution, incorporating knowledge from various sources of information as he does so. The computer system that we propose is intended to accommodate this learning process, a process we feel should be open ended, directed by the interest and insights of the designer.

1.3 Scenario

In designing a computer system to accommodate this process, we described a set of operations used to deal with a single typical design change and then described a system that could perform them. We assumed that this scenario would indicate at least a minimum of system elements which would be needed for a whole design process. Further investigation of a range of examples would be needed to confirm that the elements found in this way were not only necessary but sufficient. The scenario of going through one loop consists of 6 steps aided by 5 outputs from the computer (see Figure 3).

Step 1: a building is proposed, eg, an office building of 3 floors with columns at the edges (let us say in the form of plans containing information normally conveyed in a diagram of all floors of the building).

Step 2: the first problem is posed; what is the total cost? OUTPUT 1; total cost. Assuming this cost is acceptable, the designers fault the form because of another problem, the parking space is inadequate.

Step 3: they propose to modify the form. The form is modified; the outside line of columns is brought in by cantilevering the edge of the upper storeys to permit parking.

Step 4: the designers posed another cost problem; what is the cost of cantilevering the edges of the second floor. OUTPUT 2; total difference between Form 1 and Form 2.

Step 5: designers deem this cost unacceptable and want to know what caused it so that they may react to these causes. OUTPUT 3; a list of the building elements of the cost estimate that were changed and the magnitude of the difference.

Step 6: the designers select from this list the elements they might be willing to modify such as the slab design. They then want to know what factors have entered into the calculation of the cost to find which might be fruitful to modify, and the plausible directions to modify them. OUTPUT 4: list of factors that an architect can modify that entered into the cost calculations. OUTPUT 5: the way the total cost will vary when each factor varies over a likely range.

This scenario illustrated what kinds of interaction are desired with the computer system to help the architect to make changes to either the proposed building or its program requirements. The proposed system is not meant only to answer problems like costs or to manipulate designs automatically in response to changes in problem factors like cost. It is meant to put together information to aid the designer arrive at an understanding of the relationships between his problem and proposed design.

2: Computer System Description

The computer system we proposed to aid designers is based on the model developed from the analysis of the designers questions (Figure 2, history model) and the subsequent set of elements used to carry out the scenario of going through a typical step of design process (Figure 3, scenario). These models have led directly to the format which we used to describe the computer system. The main parts of the system are illustrated in Figure 4 and are:—

A. The project file comprising:—
    (1) Physical description
    (2) Performance description

B. Suite of operation programmes

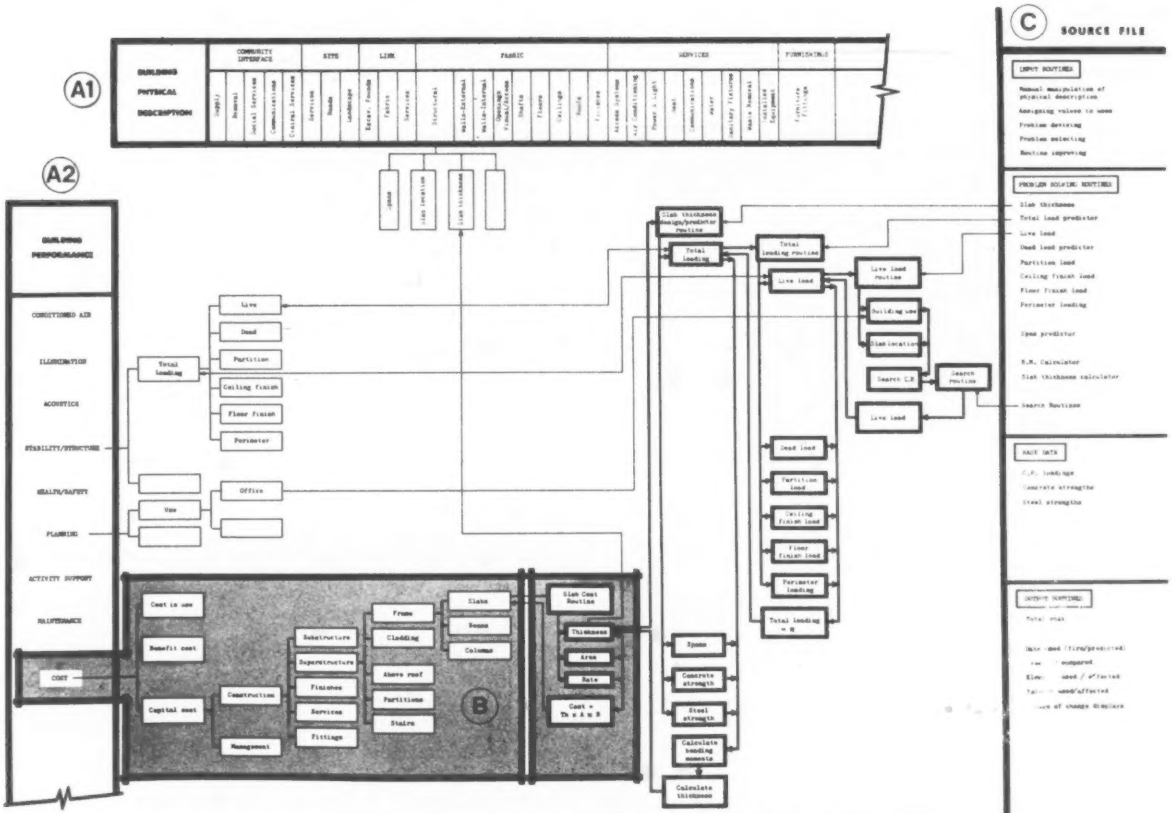
C. General source file comprising:—
    (1) Input routines
    (2) Problem solving routines (including all calculating routines)
    (3) Base data
    (4) Output routines

The details shown in these illustrations are developed for the purpose of showing the elements needed in the system to perform the specific operation illustrated only. Hence the elements, classifications, data, and operations shown are tentative, applying only to the operations shown. These would be expected to change and be augmented as more operations were taken into account.

2.1 The Project File (A1 and A2)

The project file will contain data about a designer's particular project. At the outset, it will contain no information about the project until the designer supplies it. If some data is needed to answer a question before the designer has had a chance to supply it, it will be predicted. Hence, the files are empty until the designer fills them in with a rudimentary description of his project; after that, they can be made to have information enough to answer any question. This permits the designer to investigate at any time any issue he considers important.

The project file is divided into two parts which represent the two polar interests of the designer - problem (performance required of the project, A2)


A1
BUILDING PHYSICAL DESCRIPTION
COMMUNITY INTERFACE
SITE
LINK
FABRIC
SERVICES
FURNISHINGS
Supply
Removal
Social Services
Communications
Central Services
Services
Roads
Landscape
Excav. Founds
Fabric
Services
Structural
Walls-External
Walls-Internal
Openings Visual/Access
Shafts
Floors
Ceilings
Roofs
Finishes
Access Systems
Air Conditioning
Power & Light
Heat
Communications
Water
Sanitary Fixtures
Waste Removal
Installed Equipment
Furniture Fittings
Span
Slab location
Slab thickness
A2
BUILDING PERFORMANCE
CONDITIONED AIR
ILLUMINATION
ACOUSTICS
STABILITY/STRUCTURE
HEALTH/SAFETY
PLANNING
ACTIVITY SUPPORT
MAINTENANCE
COST
Total loading
Live
Dead
Partition
Ceiling finish
Floor finish
Perimeter
Use
Office
Cost in use
Benefit cost
Capital cost
Construction
Management
Substructure
Superstructure
Finishes
Services
Fittings
Frame
Cladding
Above roof
Partitions
Stairs
Slabs
Beams
Columns
B
Slab Cost Routine
Thickness
Area
Rate
Cost = Th x A x R
Slab thickness design/predictor routine
Total loading
Total loading routine
Live load
Live load routine
Building use
Slab location
Search C.E
Search routine
Live load
Dead load
Partition load
Ceiling finish load
Floor finish load
Perimeter loading
Total loading = W
Spans
Concrete strength
Steel strength
Calculate bending moments
Calculate thickness
C
SOURCE FILE
INPUT ROUTINES
Manual manipulation of physical description
Assigning values to uses
Problem devising
Problem selecting
Routine improving
PROBLEM SOLVING ROUTINES
Slab thickness
Total load predictor
Live load
Dead load predictor
Partition load
Ceiling finish load
Floor finish load
Perimeter loading
Span predictor
B.M. Calculator
Slab thickness calculator
Search Routines
BASE DATA
C.P. loadings
Concrete strengths
Steel strengths
OUTPUT ROUTINES
Total cost
Data used (firm/predicted)
compared
used / affected
used/affected
of change displays

SYSTEM MODEL : FOR COSTING & PREDICTING SLAB DESIGN

Figure 4:

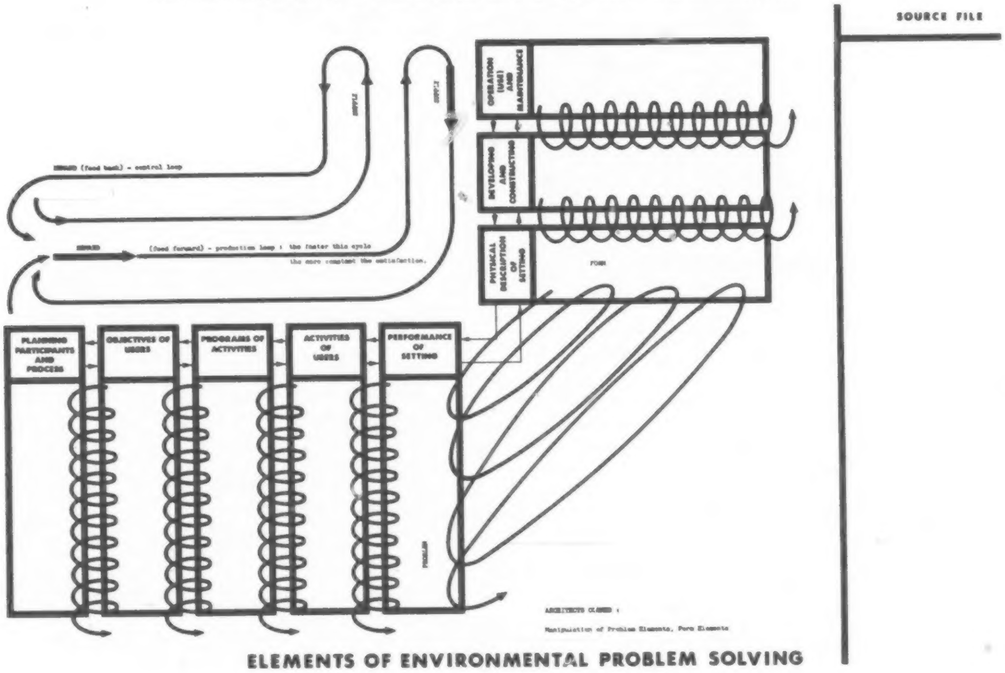

SOURCE FILE
PLANS
SUPPLY
REWARD (feed back) - control loop
REWARD (feed forward) - production loop : the faster this cycle the more constant the satisfaction.
OPERATION (USE) AND MAINTENANCE
DEVELOPING AND CONSTRUCTING
PHYSICAL DESCRIPTION OF SETTING
FORM
PLANNING PARTICIPANTS AND PROCESS
OBJECTIVES OF USERS
PROGRAMS OF ACTIVITIES
ACTIVITIES OF USERS
PERFORMANCE OF SETTING
PROBLEM
ARCHITECTS CLOSED :
Manipulation of Problem Elements, Form Elements

Figure 5:

ELEMENTS OF ENVIRONMENTAL PROBLEM SOLVING and form (the physical elements of the project, A1).

Design involves making the physical elements (A1) compatible with the client's problems, the way the building is meant to perform (A2). By means of suitable operations programs (such as design routines) the designer is able to relate and adjust these two to each other going iteratively back and forth between them, drawing information from the Source file, learning more about the relationships, judging them, changing them and proposing new ways of making them compatible.

The project file contains no information on a particular project until the designer specifies it or it is predicted. Similarly, the amount of detail in this file should be ad hoc, should be matched for the purposes they are serving. For example, we show the file breakdown needed for costing purposes (see Figure 4) one category being broken down still further (structure) to show a detail (slab thickness). There is implied here a structure that can store information about the geometry of the building, the materials of which it is built, and the details of construction.

2.2 Operations

What was described as a simple spiral (Figure 1) to represent a designer's process of relating environmental elements to the problems they solved is now represented as a flow of information pieces necessary to perform such a link. These flow diagrams are the design routines that the system is intended to use.

The relationship illustrated - that between a project and its capital cost is shown in Figure 4. This operation is a fairly simple process of listing all the separate cost incurring elements and totalling their cost. However, the figure shows that if the costs for each of the elements are not available, sub routines have to be added to arrive at each. We have listed a routine designed to calculate slab cost, which in itself is fairly simple. However, the slab cost routine needed information about the physical description of the building (the thickness of the slab), which we inferred had not yet been determined. Hence, in order to answer the designer's question concerning costs, this piece of information had to be predicted. This 'predictor' routine is comprised of going through all the steps of designing a slab - from finding the loads and spans to calculating the slab thickness. Once again, we inferred that the loadings were not available and that we had to predict them. This task included retrieving information on the use of the building (offices) in order to use the stored loading tables (from Codes of Practice). Hence, a question-answering routine is composed of the principal routine plus a number of sub-routines, for predicting each piece of information needed to answer the principal question. This raises many issues which will be discussed below: how far back should a routine search before it hits data not needing prediction; since answering one question means answering others, how independent can any one of these routines be; and who designs and selects the routines.

2.3 General Source File

This is a general file which will be always under development with information being added and changed as routines to handle it are developed. It contains not only the stored basic data but also holds routines for problem solving, design calculations, input and output routines, all in a modular form for access and use by operations programs as previously described.

Inputs and Outputs

The inputs and outputs will be the routines through which the designer communicates with the system. Because the designer must have access to all elements in the system and have the ability to change them these input/output routines are likely to be very extensive. Since we want the designer to be able to select and change all elements in the project file, operations, or data used, he must be able to change directly:

- the form(the description in the physical description file)
- the questions (the elements in the performance file)
- the predictors, the problem solving routines used
- the values used in the calculations, even those coming from the data base
- the extent of detail used in various analyses.

We have already discussed in the scenario one set of outputs that the system must have. A designer must know in general:

- what form was judged (graphic representation form and some detail description)
- what routines were used in the calculations (what predictors were operating)
- what factors were used in the calculations
- what were the various relationships between the factors
- what are the comparisons between sets of factors.

We outline these items to give some indication of the scope of input-output routines that may be needed.

Routines and Base Data

Data banks have been produced for many purposes - for generalised systems (eg ICES) or for particular programmes (heating and ventilating, structural, cost, space allocation analyses). It is our conviction that this list will always be extended so long as designers have the role of asking further questions, when determining what purposes environments can serve. We view the task of developing the data bank and set of routines for the system to use as open ended. This means that we start with a few operations and develop a generalised structure to accommodate them, doing this with a view to making that structure modular and capable of continued addition.

Predictors

We have mentioned predictors as being necessary to add information to the project file in order to permit questions to be answered at any stage of the design process. A prediction routine is the articulation of the steps a designer goes through when performing a design operation. The primary source for such routines in the future should be the users of the system. If the routines are in a modular form that its users (the designers) understand, and if the users are made aware of the nature of the routines operating, they can choose to modify them or to develop new ones to perform operations for which no routine is available. There will be a large overhead on the system to permit the user to do these things. This is seen as a necessary feature because the understanding of the designer is needed for him to contribute to the development of the system, as well as to allow him to exercise judgement and act on new insights.

Control of the extent of detail

As can be seen in Figure 4, calculation of the cost of a slab, one predictor is embedded as a sub-routine in another. In fact, any problem solving routine can be used as part of some predictor. For example some predictive routine (such as one for selecting a roof finish)might need for its own operation to establish what kind of roof finish can be afforded. In doing this it would need to know how the total cost of a described project compared to a preset budget. Hence, the cost calculating routine becomes part of the roof finish predictor designer routine.

This interconnectivity stems from the fact that design elements are inter-related, and are interrelated for an enormous range of purposes. It is one of the critical tasks of designers to designate the cut-off points - to say what would be the worthwhile extent of any analysis being run. As will be stressed below, a critical element of this system for a designer to control is the extent to which relationships between building elements and functions are traced. He should be permitted to trace them as far as he is interested and to extend the capability of the system to make such links where he deems it important to do so.

3: Scope of Proposed System

We stress that the system we have been describing is intended only for the purpose of providing cost estimates at early stages of design. Although the aims of this system were formulated from the standpoint of how costs related to an acutal design operation, we have extrapolated from that study to describe a system suitable for many design operations. Let us look more closely at what might be the limitations of this study to see what other kinds of efforts are needed to extend this work.

3.1 Need to be Comprehensive

First, we have only looked at the link between the performance of a building (stated in terms of cost) and and built elements listed in a format suitable for this (see system model Figure 4). This sketch can be extended to include other elements of environmental problems (see Figure 5) that are inevitably either directly or indirectly taken into account by a designer. The resulting diagram is a supply-demand cycle with the designer responsible for adjusting the performance of a setting demanded to the description of the environment to be supplied. In Figure 5, we trace the performance of the building back to the source which occasioned the demand for the building, the objectives it meets or problems it solves, then to the programmes, sets of activities needed to solve the problems, and finally to the specific activities that the environment is meant to support and enhance. In the other direction we trace the built elements of the environment back to the considerations involved in supplying elements of the environment - developing, constructing, and then maintaining and using them. This abstract model does not represent a new or proposed context for designers: it is only a crude model of the situation they are in now. We are not trying to extend the role of designers through giving them a computer-based set of operations - rather we are suggesting that they need to articulate the complex relations they deal with to operate better in their primary role as form-space handlers.

3.2 Need for Ability to Handle Relationships in all their Complexity

The first thing to note about the model, Elements of Environmental Problems (Figure 5), is that all of its elements are linked in ways at least as complex as the few links we have traced earlier (between cost and built element). As every designer knows, each time he manipulates one element of his building, there are ramifications throughout the building system - some good and some bad. Present methods of providing cost information for alternative design solutions do not permit adequate consideration of all the interacting factors. Nor are designers able to trace the consequences of their acts back as far as the construction process details which are the actual sources of cost.

Another shortcoming is also apparent when we look at how difficult it is for architects to trace the consequences various design proposals have with respect to the needs of the project's users. These are very important sets of consequences to the users, the benefits from which may far outweigh any construction cost difference. Yet designers are practically powerless to trace these connections.

The case history of the Crown office building studied seemed typical; designers never traced the consquences of every decision very far. The relationships between decisions made on different topics quickly became too complex to handle. For example, it was not possible for the designers to relate a feature of the Crown office building design to the construction operations necessary to build it. However in our study we found that it was possible to codify the decisions contractors make in putting together their operational schedule from a set of plans, demonstrating that it is possible to relate this chain of reasoning to developing designs and to give designers costs based on contractors' operations. Also we have found that frameworks can be devised to articulate the connections between building elements and the purposes they serve, the benefits they give their users. Yet to trace these skeins - to relate the contractors' costs to the building elements and these to the users' benefits, and then to apply these relationships to a design that is developing - is very difficult and is never done extensively enough.

As a result designers will always suboptimise. They decrease this danger as they trace more complexities and they can apply more knowledge to the design at hand. Unless a computer system is available that will be comprehensive enough to handle these complexities, we will never be able to take into account much more of these kinds of complex relationships. Hence, the system recommended must be able to handle relationships in all their complexity and apply them to the designer's particular problem and design.

The benefits from being able to make such improved decisions should justify the cost of efforts to achieve such an extensive system. Since what will be discovered is not yet really known and therefore can not be evaluated, it is important to realize at least that it is crippling and shortsighted not to aim for developing a system that will permit these problem elements to be traced in as much extension and complexity as possible.

3.3 Need for Increasing Designers Understanding and Ability to Select Areas to Investigate

From the case history studied, we found that the designers were constantly engaged in searching out the various consequences of design decisions - sometimes trying to find ways to adjust the interpretation of their clients' problems to their designs, sometimes adjusting their design. They were always going back and forth between problem and design, learning more about the problem and form, learning better ways to adjust these elements to each other as they proceeded.

We consider that the prime value of the designer is his ability to learn and have consequent insights, and that a prime requirement for a computer system is to aid the designer in his learning process and then permit him to exercise his new judgements. Unless it is interactive - can handle the patterns and connections the designer wants to trace, permit him to manipulate them in order to help him develop an understanding of their relationships - the value of a designer may be decreased. This is relatively easy to avoid; the system should be able to display the information and routines that the designer is using in answering his questions and then formulate answers in a way that will tell him what might be the most strategic direction to take.

How much information an architect can absorb is a very serious issue. As we indicated in the discussion of the scenario, the design process is a learning one. A designer creates, proposes, a design and then proceeds to investigate it - to see what problems it poses and solves. If he is to proceed further, he must understand the consequences of various design moves - the reasons for what happens. Hence, not only must the designer be able to learn the results of some other specialists' analysis (whether it be fed to him through a computer routine or directly from the consultant), he must have access to the specialists reasoning as well.

If this does not happen, much of the value of having a profession like a designer is lost. Just as a cost estimator can be replaced by an automatic calculation routine to provide estimates where they can be done by procedures which only need be repeats of ones used before, a designer can be replaced by routines which will put together building elements based on past reasoning. (Our predictor/designer routines are based on this observation). What is important in having a person do the work is that he will learn, have insights that may come from rejudging past situations, thinking of improvements, or creating new possibilities.

Not only must the system permit the designer to investigate many consequences that take place, he must be able to pursue nets of cause and effect in any direction his insight leads, putting together new connections in such nets, putting together new routines for generating new situations. Unless a system provides him this freedom to investigate and to formulate as his judgement, insights and understanding dictate, the system will become a restraint on his abilities rather than a help.

3.4 Need for Transmitting Insights and Developing the System Through Use

When we describe the ability to put together new design prediction routines, we are requesting this freedom to formulate; and when we describe the output routines which indicate how the computer came up with certain design evaluations, we are illustrating how the computer can aid the designer's ability to gain insight. Though providing these amenities may be difficult and a somewhat costly overhead item, there is one gain from giving the designer this kind of open ended system that will make these worthwhile. The fact that these calculations and formulations will be carried out in the context of a computer means that they will have to be recorded in detail and can be preserved. Hence, what one designer does in this context can be examined and understood and even improved upon by another. If this is going on in the context of a system with the scope illustrated in the sketch of

Elements of Environmental Problems (Figure 5), the amount of relationships that are traced will be increased through further connections being made by designers and detailed knowledge of how elements affect each other will grow. (We refer for example, to the development of the vocabulary of predictor/designer.)

Though this may compound the amount of knowledge a designer is expected to master, it will for the first time in the history of the profession be possible to start to build on the thinking of other designers in an exact way and to transmit insights exactly. For example, when a designer has an insight such as that there is a benefit to making office spaces interconnect to improve communications, the only way he can transmit this insight is through his plans being published in journals. Architects can generally mimic the form after seeing this, but the reasoning does not necessarily get transmitted, especially in a way that another designer can 'build' on it. At present such developmental dialogues are carried out in such vague or pictorial terms with ill-defined and unqualifiable elements that it is rare for concepts to be developed in dialogues between office and office or from project to project.

As this system develops, a whole new set of terms and grammar of connections may develop. For example, as we connect the costing routine to the built elements, we find we need 'predictors', which seem to be modular. We have not inspected in any detail what such modules are like; yet we look forward to finding new classifications of design problem elements stemming from what different modules need to be developed. From this, it might become apparent what are relatively independent unconnected design issues and why some are so, and which issues have rote methods of solution and which are judgemental. In other words a meta-language for design, a way of talking about very basic issues in design, may emerge.

3.4 Need for Improved Communications and Graphics

It is obvious from the chart of the Elements of Environmental Problems, that there are numerous areas of concern that impinge on the designers' problems and much interconnectivity between them. Since each of these areas is the bailiwick of several specialities, inevitably the problem of communications between them becomes an issue.

In this study we are particularly interested in communicating with the designer, and we must recognise that a major part of his work deals with form and form changes. From Figure 1, an important thing to note is that practically all the capital cost questions relate to the form of the building. This is not surprising since this is one of the central concerns of the architect and the thing which incurs capital cost. This fact however introduces need for graphic input-output devices to give the designer some easy way of relating his forms to the costing routines. In addition, this fact indicates that all cost information should come in a form which is easily related to the building forms that are incurring it. Information about total costs or costs per square foot are not adequate for this purpose. This chart makes us, then, stress the point that the computer system must focus on form, must relate information to the form the project is taking if it is to be of help to designers, the people whose prime responsibility is that of handling form. The input-output devices ideally should be as varied as the information handled. It could come from plotters, high speed printers, tele-tapes, CRTs: it could be in the form of graphs, drawings, text, formulae, diagrams, lists. In other words, the format of interaction with the computer depends very much on the concerns being dealth with and the ability of the computer to communicate.

There are many questions which relate to this issue of communications that will become important in setting the details for how the system is to run - eg how to communicate with each specialist, what role consultants will play in the development of the system, what information is to be general and what developments proprietary. These can only be decided once the context and scope of development are defined.

To achieve a computer system that will evolve into a comprehensive one, a minimim first step must include four features:

1. Files derived to support the design operations (project files and particularly a general data base)
2. Some rudimentary design operations for computerisation.
3. A working context for initial development
4. A study of the modularity of the system and other elements needed to keep it evolving, including the developments of an administrative mechanism for assuring its continued evolution.

It seems inevitable that it will ultimately become possible to handle the complex elements of environmental problems, but it is questionable how readily designers will learn to use such knowledge and apply it to their problems. Without co-ordinated development of the computer system they may not be able to do so at all or possibly this ability will be developed very inefficiently. To permit all complexities to be traced, to help designers understand them and learn from them, to contribute from their insights, and to continue to grow as designers contribute, the system must be as comprehensive and interactive as described.

Notes

[1] This paper is based on material developed while preparing the study "Improving Design Decisions: Outline of a Computer System Particularly for Handling Costs" done for the Directorate of Quantity Surveying Development, Ministry of Public Buildings and Works, June 1970, under the direction of D. Bishop. Team members involved in this work were D. Beeston, J. Buchanan, A. Fuller, P. Ostler. This paper does not represent official views; it is only a summary of some of the thinking involved in the original study.

GRAPHICS SYSTEMS FOR COMPUTER-AIDED DESIGN

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It is now ten years since Sutherland (1) and Ross (2) first proposed the use of graphical displays in computer-aided design. In the intervening period computer graphics has been the focus of a great deal of research and development effort by universities, manufacturers and research organizations. The results have been disappointing. There has been scarcely any further development beyond Sutherland's SKETCHPAD of a cohesive approach to computer graphics programming, and the cost of high quality display equipment has not dropped at the same rate as other computer equipment. As a result, computer graphics remains difficult and expensive to apply to design.

Faced with such a discouraging situation, we may be tempted to dismiss graphics as one of the failures in the history of the computer, or at least to think in terms of several more years' research and development before computer graphics can be of use to the average architect, engineer or graphic designer. In the writer's opinion, however, these attitudes are needlessly pessimistic. There are exciting possibilities for the use of graphics in design in the near future, provided we depart somewhat from the traditional approach to graphics system design and make use of some recent developments in hardware and software. The purpose of this paper is to describe these new departures.

I. Problems of the past

Many of the difficulties that have been experienced with computer graphics have been the result of misplaced enthusiasm for the graphical display. It is very easy to devote so much effort to the development of graphics software that one loses sight of the application that was the original objective. There are indeed many fascinating problems to be faced in building graphics software for the support of CAD -- how to refresh the display, how to define a structured picture, how to interact graphically with it. However these problems should not dominate the fashion in which we approach CAD. The main task for the computer is to help solve the designer's problems. Some of these problems may be best solved with the aid of graphics, some without. The designer should be able to use graphics when it is appropriate, rather than being forced to use it all the time.

Thus one way in which we can begin to make better use of computer graphics is to stop making graphics the focus of our CAD systems. A second is to avoid being too ambitious in our concept of what a CAD system should be like. A very common example of over-ambitiousness is to set out to build a CAD system that can be used by designers with no knowledge of programming. Although one may succeed, one generally has to ask the designer to learn a command language that is in many respects similar to a programming language. It may be better to teach the designer a simple general-purpose programming language and let him write his own application programs.

This latter approach has much to recommend it. In particular it solves the problem of how to design a CAD system when we are not quite sure what it is to be used for. Many systems have been designed in such circumstances, in which the only logical approach seemed to be to include all the features that the user could possibly want. As a result these systems took many man-years to develop and in the end could be run only on the largest computers. Not surprisingly, these systems have generally proved too expensive for the average designer to use.

II. New approaches

We have suggested that one way to achieve wider use of graphics and CAD is to teach the designer to program. This may at first seem impossible. How, we may ask, can we teach our designers to understand the XYZ Fortran Graphics System when the programmer's manual alone runs to 450 pages and we can hardly understand it ourselves? The answer is that we shouldn't be using the XYZ System if the manual is 450 pages long. What the designer needs for problem-solving is a simple interactive language in the category of BASIC and APL, that he can learn in a few days and that he can use without any of the traditional frustrations of job control cards and Fortran input-output. In the writer's opinion neither BASIC nor APL is an ideal designer's language, and a block-structured language such as Wirth's EULER (3) is much better. However, any such language is preferable to languages like Fortran that were never intended for use in interactive environments.

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Even if we can teach designers to program, how can we hope that they will understand computer graphics, well known to be one of the most obscure fields of computer programming? The answer here is much as before: we should use simpler graphics languages. We should avoid systems that involve the use of complex graphic data structures, and instead encourage the user to think of the display as a simple output device on which he can create pictures much as he would on a digital plotter. Graphic data structures have for years been considered the only basis for creating complex displayed pictures. However they are very difficult for the novice programmer to understand. A much simpler approach that is equally powerful is the notion of representing pictures by procedures (4). This technique has been used in an extended version of EULER called EULER-G (5), in which it is possible to define symbols as procedures and then include them in the picture by means of statements such as the following:

```
door at [120,15] scale 2.5
resistor at [0.5,2.5]rot pi/2
```

The procedures like door and resistor that we call in this way may represent simple symbols, or may be more complex pictures made up of calls to other procedures; thus we can define pictures in this way that are just as highly-structured as any picture we create with the aid of a graphical data structure.

It has for years been said that an essential in any CAD system was the ability to create large, highly inter-connected data structures. In this way one could model the design under consideration and could modify and analyze the model during the design process. However, it is not easy to write a program that maintains a large data structure of this kind and that permits various alterations and analyses to be made. A much easier way for the novice programmer to organize his data is by means of files which are stored on a disk or similar storage medium and which the program can read and create by means of very simple input and output functions. In an environment of this sort, an application program need not maintain a large or complex data structure: it can scan the appropriate files, set up a few lists of data representing a small subset of the filed data, and display or analyze this data.

III. An example of an application

The ease with which languages like EULER-G can be used is illustrated by the following example. The application concerns computer-aided design of a rather unconventional kind, namely the design of political districts. Political redistricting involves a great deal of laborious computation. A large number of different arrangements of boudaries must be tested, not only for their political acceptability, but for such things as equality of population living within each district. Thus it is necessary to make an accurate estimate of the number of people living within each district, and if any large discrepancies are found the boundaries must be adjusted.

To demonstrate the potentialities of computer graphics in this area, a small program was written in EULER-G, using an IMLAC PDS-1 display and a PDP-10 computer at the University of California, Irvine. An area of Los Angeles was digitized and a file of street names and coordinates was created. Then a second file of the coordinate positions of all the voting precincts was created. With the aid of this file and a file listing the population and voter registration figures for each precinct, it was possible to produce a list of data from which the program could compute the population and voting characteristics of any given district.

The organization of the program was then very simple. The program displayed a map of the region on the screen; the user could alter the scale and the locality of the map, and could identify streets by pointing to them with a RAND Tablet stylus, whereupon the program would display the street name.

This gave the user enough visual cues for him to draw a boundary, again by means of the stylus. When the boundary was complete he could ask for voting and population figures to be displayed. Figure 1 shows the map, a typical boundary and the displayed results.

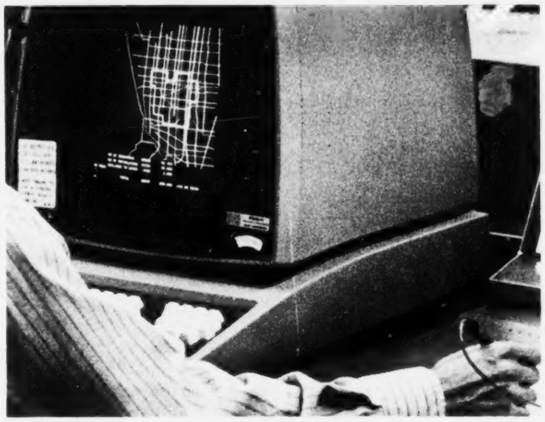

Figure 1

The program permitted existing boundaries to be modified and tested in a repetitive fashion in order to find an optimum arrangement. Boundaries could be saved on the disk and recalled later. It was possible at any point to generate a hard-copy version of the picture on the screen by means of a digital plotter.

The entire program took one person less than a week to write. This was possible only because of the powerful features of EULER-G for file-handling, for creating scaled, structured pictures by means of display procedures, for handling stylus interaction, and for generally expressing complex algorithms in a straightforward manner. From this it might be thought that EULER-G is a very complicated language; it is not, and has in fact been used without difficulty by students with no previous programming experience.

Future developments in computer graphics

Although languages like EULER-G can simplify considerably the task of writing graphics application programs, the problem remains of the high cost of computer graphics. Graphics is expensive for two reasons: firstly, display terminals are themselves expensive; and secondly it is very expensive to provide the sort of rapid interactive response that the graphics user needs. At present the cheapest way to provide interactive graphics is to use a storage-tube terminal and attach it to a time-shared computer system. This is not very satisfactory, nor is it particularly cheap. Storage-tube displays produce small and rather low-quality pictures that are barely adequate for design applications; moreover they are unsuited to highly interactive computer graphics. The use of time-shared systems reduces the speed of response of the program. Thus the general effect is to degrade the quality of service that the user receives.

Even if the user should be satisfied with the cost and quality of such equipment, he will be dismayed by the amount of money that it will cost him to use. Time-shared systems are inexpensive only as long as interactions are kept relatively infrequent and involve only a small amount of computation. Unfortunately graphical interaction breaks both these rules: it happens at a fairly frequent rate, particularly if a stylus is in use, and it uses a lot of computer time because of the amount of scaling and clipping that must be done to each picture. So the user is forced to cut down on his interaction with the system in order to keep his costs within reasonable bounds. This is defeating the original purpose of interactive graphics.

At this point we should ask ourselves if time-sharing is really the right basis on which to build an interactive graphics system. These problems of degraded picture quality and response were unheard-of in the early days of computer graphics, when all research was done on stand-alone, single-user computers like Lincoln Laboratories' TX-0 and TX-2. When graphical displays first came on the market they too were attached to stand-alone computers. However at that time powerful computers were expensive, and for economic reasons the computers with which displays were used were small and relatively limited in their capability. It was for this reason that graphics system designers turned to time-sharing in search of a solution.

Since then the cost of small computers has dropped dramatically and their performance has risen, so that we can now purchase for a few thousand dollars a computer that can in many respects match the performance of a time-shared computer. Moreover in the respects that affect graphics a small machine can do much better. It can guarantee a rapid response to any interactive input; and it can offer the user a system that he can use as heavily as he wishes without having to worry about the cost of each transaction. The disadvantage of the small machine is that it cannot accommodate large data bases; this is not a problem, however, if we adopt the approach suggested above of avoiding large data structures and instead using data files kept on disk. Thus the small machine offers a simple and inexpensive basis for an interactive graphics system.

In the near future we may therefore hope to see the emergence of small, powerful interactive system, each capable of supporting a single graphics terminal, and costing little enough that any designer who can put such a machine to full use can afford it. If this can be combined with the development of simple but powerful graphics languages, we should shortly see the beginnings of a renewed interest in computer graphics as a designer's tool.

Acknowledgement

I wish to thank Dr. J. Barkan for his assistance in developing the redistricting program.

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LOCATING INTERMODAL TRANSPORTATION TERMINALS IN METROPOLITAN AREAS: A MAN-COMPUTER PROBLEM-SOLVING APPROACH

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1. Introduction

As our large metropolitan areas become even larger and more complex, the problem of locating new (or relocating old) intermodal transportation terminals or transfer stations can be expected to become more acute. The purpose of this paper is to present an approach to solving problems of this type that is based on the idea that man's intuitive ability, when coupled with a machine's computational ability, can be a significant part of the problem-solving process. The problem of locating several intermodal transportation terminals in an urban area is a combinatorial problem of very great dimension. For example, if we should wish to locate 5 terminals in an urban area and if there are 77 possible and feasible locations to choose from, there are 19,757,815 possible ways that this can be done (i.e., of selecting 5 locations from a set of 77 possible locations). Obviously, there are a great number of these possible 5-center location patterns that one would not even consider as being feasible. Still there are a great number of alternatives that do need to be examined in some systematic way. Our approach to this problem is based on the idea that man's intuition can be of significant use in guiding a computer-assisted search of the combinatorial space that contains all possible solutions.

It is recognized that mathematical programming techniques have been employed extensively to find optimal solutions for problems of this type. However, the intent here is to develop a problem-solving technique that can be used to probe problems that cannot presently be formulated and solved as mathematical programs because they contain non-linear and discontinuous functions, discrete variables, ill defined trade-off functions and are very large in size. While it may be possible to use mathematical programming techniques to find optimal solutions for problems with these characteristics at some point in the future, Scott [4] indicates that it will be some time before such techniques can be expected to be widely available. Thus, alternative approaches which can provide a near-term problem solving capability need to be developed that can handle real world problems at a reasonable cost. The approach explored in this paper will not, in general, lead to the identification of an optimal solution. It probably will produce a very good or near optimal solution which will be satisfactory (both in terms of its performance characteristics and the cost of obtaining it) for many real world applications.

This paper is divided into six parts. An introduction and definition of the class of problems to be addressed is given in the first two parts. In the third part, the components and characteristics of an interactive man-machine problem solving system called LOCATOR are described. Two heuristic man-machine search techniques are developed and applied in the fourth part of this paper. The results of an experiment which was designed to assess the utility of human intuition in solving problems of this type are given in the fifth part of the paper. Some general conclusions are given in the final part of the paper.

2. Problem Definition

The general class of problem that we are concerned with is generally referred to as the "location-allocation" problem in the literature. An excellent review of recent work in this area is given by Scott [4]. The work of Cooper [1] was of great assistance in the conduct of some of our earlier studies of this type of problem (Symons [5] and Schneider [3]). The interactive problem-solving experience reported by Rapp [2] has also provided a substantial stimulus to the conduct of the work reported in this paper.

In its most general form, the location-allocation problem is very formidable. However, the general problem can be greatly simplified by introducing a number of assumptions and this has been done in our case in order to permit us to focus on defining the role of human intuition in problem-solving activity of this type.

2.1 Generalized Problem Definition

The problem we will deal with in this paper is defined as follows:

Given Conditions and Assumptions

1. An urban region is given and represented as a network consisting of nodes and links.
2. The number of persons at each node of the network who need to travel to an intermodal transportation terminal during a given period of time is known.
3. Every node of the network is an acceptable location for a transportation terminal.
4. The number of terminals to be located is specified.
5. The cost of locating a terminal is the same at each node and is not a function of the size of the terminal.
6. All arterials and streets are congestion free at all times.
7. All persons are presumed to know (or to have the ability to determine) the location of the transportation terminal nearest them and they all take the shortest path from their location to such terminals.
8. The size or capacity of each terminal is not limited in any way.
9. Only one (average) mode of transportation is available. Thus, the speed on each link represents the average speed of any modes that might be available in the urban area.

To Be Determined

A terminal location pattern that satisfies two objectives:

1. No person is located more than X minutes from a terminal facility.
2. The total travel required for each person in the region to reach a terminal is no more than Y minutes.

In essence the task is to find a terminal location pattern that places such facilities as close as possible to the people who will use them. The approach to the solution of this problem that has been used to develop the LOCATOR System utilizes an iterative procedure. The human analyst makes an initial guess at a solution. The computer evaluates this solution with respect to the objectives adopted initially. The human analyst studies this evaluation and makes a change in his initial solution that he thinks will improve it. The computer evaluates this solution and the human analyst learns whether or not his guess did, in fact, produce a better solution. This process continues until a satisfactory solution is obtained or until the analyst is exhausted of ideas about how to improve it. This is essentially a trial-and-error procedure and the LOCATOR System was designed to enable it to be conducted within a real time environment involving a substantial amount of interactive communication between the analyst and the computer.

2.2 Design of a Specific Test Problem

The particular problem that has been used to develop the LOCATOR System is that of determining locations for V/STOL terminals in an urban area. Initially, a hypothetical city was designed which was square in shape. It was divided into 49 square zones of equal size for analytical purposes (see Figure 1a). All areas of the city are residential except for a central business district (CBD), an industrial area, a park and a lake. The basic street pattern is a rectangular grid network which connects the center of each zone to the centers of all other zones. An irregular arterial street network has been superimposed on the basic grid network. The average speed on these streets is 40 miles per hour while it is only 20 miles per hour on residential streets. Access between the arterials and the residential streets is possible wherever they intersect and two-way travel is permitted on all streets.

The intersections of the residential and arterial street networks form 77 locations (i.e., nodes), each of which is assumed to be a suitable location for a V/STOL terminal. The problem is to find the "best" 5 of these 77 locations. As mentioned previously, there are 19,757,815 different ways to select 5 locations from 77, so this is a search problem of very great dimension.

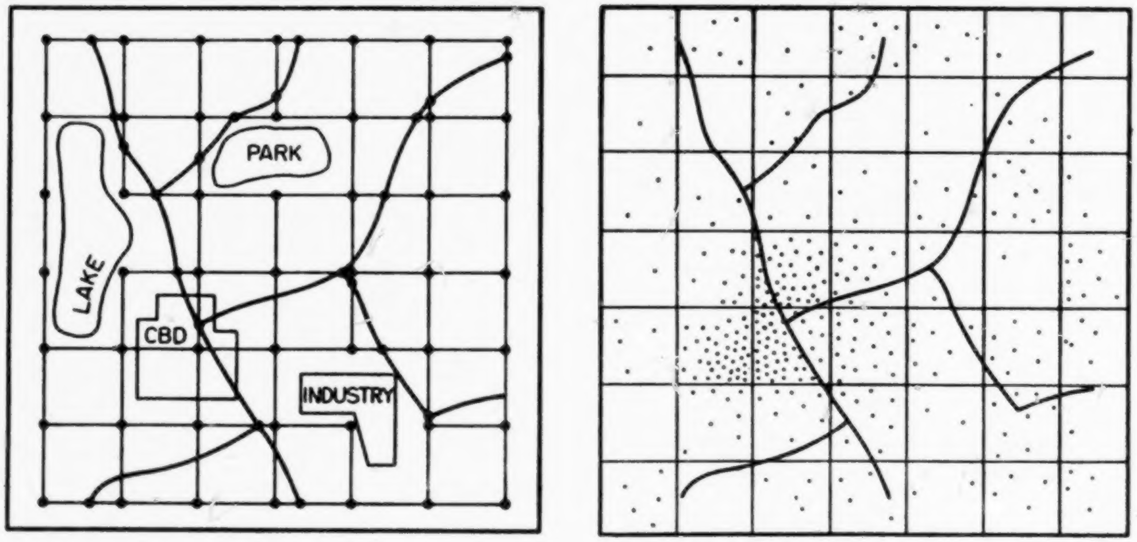
As shown in Figure 1b, the demand pattern to be served in the hypothetical city indicates that most of the V/STOL travelers are clustered in and around the CBD and are relatively few in other parts of the city. All of the people in each zone who desire to travel to a V/STOL terminal are assumed to be located at the center of their zone (i.e., the node formed by the intersection of the residential street system).

The objectives adopted for this problem are as follows:

Locate 5 V/STOL terminals such that:

FIGURE 1

HYPOTHETICAL CITY



1a Transportation Network

━━ Arterial Street

── Residential Street

● Possible V/STOL Terminal Location

1b Demand Pattern

── Zone Boundary

.˙.˙.Expected V/STOL Passengers (Ten Per Dot)

1. No trip from an origin node to a V/STOL terminal is longer than 8.5 minutes.
2. The total time required for all of the people in the system to travel from their origins to the nearest terminal is less than 26,000 minutes.

A satisfactory solution is one that satisfies both of these objectives.

It has been shown by Schneider [3] that a human analyst can examine the maps shown in Figure 1 and then design a reasonably good solution intuitively. These results give support to the idea that an analyst could also probably find ways to improve his initial solution, if given a quick evaluation of the characteristics of his initial guess. If this is true, then one might expect that a human analyst could intuitively derive a series of changes to the system which would, more often than not, lead to higher levels of performance in terms of the specified objectives. This will be true if the analyst can understand the nature of the relationships involved sufficiently well to be able to think of ways to change the facility locational pattern that will, more often than not, produce better results.

To test these notions, an interactive man-machine problem solving technique has been utilized. Its components and characteristics are described in the next section of this paper.

3. LOCATOR--An Interactive Location-Allocation Problem-Solving System

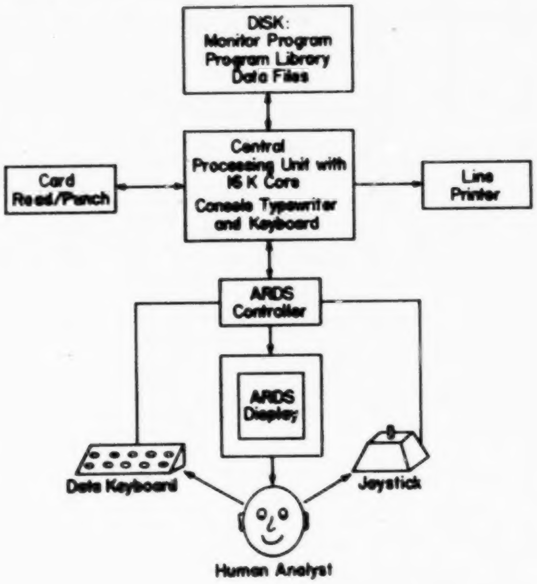
3.1 Hardware Components of the LOCATOR System

The characteristics of the LOCATOR System can be described in terms of the hardware components utilized and also in terms of the roles of both the human and the computer in the problem-solving process.

The hardware components utilized in implementing the system are illustrated in Figure 2. The basic units are a stand-alone IBM 1130 computer with a 16K memory (16,000 16-bit words of core storage) and a one-half million word disk. On line with the computer is a card reader, line printer and an Advanced Remote Display Station (ARDS). The problem is presented to the human analyst in graphic terms on the ARDS scope and he makes his aspatial (alpha numeric) inputs to the LOCATOR System with the ARDS Keyboard and his spatial inputs with the ARDS joystick.

FIGURE 2

COMPONENTS OF THE LOCATOR SYSTEM AND DATA FLOW LINKAGES



An interactive problem-solving system requires a computer facility which provides fast response time and a flexible, easy to use, input/output terminal.

In the system configuration shown in Figure 2, the entire computer is dedicated to the interactive problem-solving activity, and thus provides as fast a response time as the hardware can deliver.

The hardware system utilized in this application is a low-budget installation and has some limitations. The ARDS scope is a storage-tube scope, rather than a refresher-tube scope. In order to display a change, our system must erase the screen and redraw the entire display, as modified only by the new or relocated facility. This erasure requirement seems to have some undesirable psychological effects in that several persons have noted that it tends to break the continuity of the thought process involved in the problem-solving effort (i.e., it tends to "erase" some of the thoughts in your mind). Nevertheless, the hardware system does provide the basic environmental requirements for an interactive problem-solving activity quite admirably in terms of its fast response time and its flexible input/output characteristics.

3.2 Operating Characteristics of the LOCATOR System

The analyst is intially presented with a graphic display of the problem on the ARDS scope. Figure 3 is an ARDS display of the same data that is illustrated in Figure 1. The number of V/STOL travelers at each location is represented by hexagons of various sizes centered on each node of the network. It is possible to annotate this display more completely but this has not been done in this case to retain graphic simplicity. Next, the analyst types the number 5 on the ARDS Keyboard to indicate that he wishes to locate five terminal facilities. He then proceeds to select five locations (nodes) with the ARDS joystick which controls a blinking-dot on the face of the ARDS scope. After he has selected five terminal locations, the computer calculates the shortest path through the network from each terminal to each origin node. It then assigns all of the people at these origin nodes to the nearest terminal facility, computes the total travel required for each person to reach a terminal and identifies the longest trip to each terminal. The evaluation is presented to the analyst within a few seconds in the form shown in Figure 4. The analyst examines this information and develops an idea as to how the performance of the system might be improved by changing the location of one or more terminals. He then makes these changes and then is presented with an evaluation within a few seconds. As he proceeds with this iterative process, he may, at any time, call for a summary of the results of his efforts in both numerical or spatial terms. He may also delete or add facilities in those cases where the number of termials is not given and he wishes to determine the

FIGURE 3

THE ARDS DISPLAY OF THE NETWORK AND DEMAND PATTERN AT EACH NODE

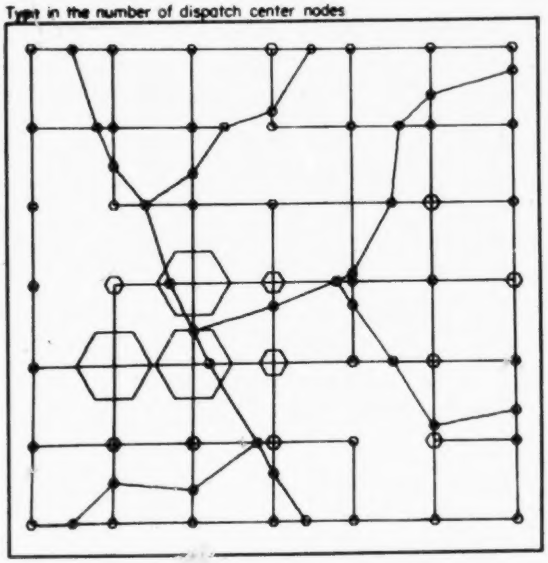
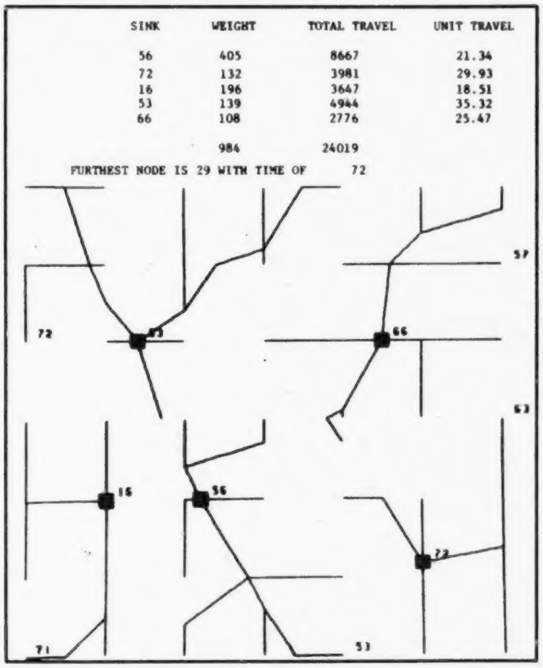


FIGURE 4

THE ARDS DISPLAY OF AN EVALUATION OF A TRANSPORTATION TERMINAL FACILITY LOCATION PATTERN



SINK	WEIGHT	TOTAL TRAVEL	UNIT TRAVEL
56	405	8667	21.34
72	132	3981	29.93
16	196	3647	18.51
53	139	4944	35.32
66	108	2776	25.47
	984	24019	

FURTHEST NODE IS 29 WITH TIME OF 72

effects of increases or decreases in the number of facilities on the performance of the system. It is also possible to vary the demand pattern in those cases where it is necessary to deal with more than one demand pattern (e.g., a "high" forecast and a "low" forecast of the anticipated demand for a transportation service).

The computations are performed so quickly that the analyst becomes involved in a conversational situation with the computer. However, since he controls the speed of the conversation, he can take as much time to think about a particular situation as he wishes to.

Operationally, the analyst selectes an option from a menu of options available to him. These options represent program modules which perform the operation the user requests. There is no particular order required for selecting options. Certain options are designed for working directly with the basic problem (as described in section 2.2), while others provide convenience, bookkeeping and evaluation features.

The program has a central executive monitor which controls the selection of modules. The user may interrupt the operation of any module at any time during calculation and specify a new option, should he change his mind about a particular direction he was taking, or have an idea about something he wants to try before he loses his train of thought. The objective of this design is to provide the user with as flexible a tool as possible, since we are trying to encourage the generation of ideas which can be instantaneously evaluated, leading to pursuing the idea further, or rejecting it as being unproductive in some sense.

The waiting time for most operations is in the range from immediate response to about 4 seconds, depending upon the request and the state of the machine. At present, considerably more time is spent waiting for the display to become ready than is spent in actually calculating the minimum-path trees and computing the evaluation measures. Still, an analyst familiar with the operation of the program can test a location design in slightly over one minute.

3.3 Initial Operational Experience

The initial operational experience with the LOCATOR system indicated its potential utility. The problem described in Section 2 was "solved" in a previous study by Schneider [3] with a computer-based search procedure. In this earlier study, 10,000 different solutions were selected at random and evaluated. The "best" of these was used as a basis for assessing the capability of human intuition in solving problems of this type. When the LOCATOR System became operational, this "best" solution was used as a starting point for the initial exploratory search experiments. The very first move made by the analyst produced a better solution than that produced by the 10,000 trial procedure used previously. Since that initial experience, more than 100 solutions have been found with the aid of LOCATOR which are better than this previous "best known" solution. While all of these better solutions are only slightly better than this solution these results do indicate a potential for "discovery" that the availability of the LOCATOR System provides.

The initial exploratory experience also clearly indicated that some simple heuristic techniques could be developed that could be used by the analyst to rapidly search the "space" around any particular solution. These heuristic techniques were designed to simulate the most successful of the trial-and-error procedures used in the initial exploratory work. The heuristic techniques were applied to find a very good solution to the test problem which could be used in subsequent experiments as a basis for evaluating the capability of human intuition in the derivation of acceptable solutions to these types of problems. The heuristic techniques and our uses of them are described in the next section of this paper.

4. Development of Two Heuristic Search Techniques

Since there are two objectives to be satisfied in this problem, two heuristic search techniques were developed. One was designed to search only for ways to reduce total travel and the other was designed to search only for ways to reduce the length of the longest trip. The algorithms used in each case are described in turn.

4.1 The Total Travel Reduction Heuristic (TTR)

This heuristic, called TTR, was developed to search for ways to lower the total travel required in the system. The analyst selects an initial (starting) set of facility locations and then calls up TTR to systematically move facility locations around until it cannot find any way to further reduce total travel.

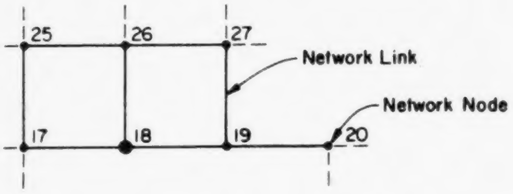
This heuristic is simple and transparent. Its virtue lies in its ability to operate much faster than a human could in searching the space around a particular solution. It also keeps an accurate record of what it does, in both absolute and relative terms. Given the list of node numbers in the starting set of facility locations, the TTR process is initiated at the first node on the list. Each of the nodes which are directly connected to this facility location node is examined to determine whether or not moving the facility to one of these nodes will produce a lower total travel figure.

Figure 5 illustrates a case where three nodes are directly connected to the facility at node number 18. In this case, the facility at node 18 would be temporarily moved to nodes 17, 19, and 26 by the heuristic and the computer would calculate the total travel associated with each of these situations. This process of evaluating the changes in total travel that result from moving a facility to its neighboring nodes is continued until no further improvement can be made. Thus, if the node 19 location produces a lower total travel figure than either nodes 18, 17, or 26, the facility location would be changed from node 18 to node 19 and then the nodes adjacent to node 19 would be evaluated in turn. In this case (see Figure 5) nodes 20 and 27 would be evaluated but node 18 would not be re-evaluated since the heuristic technique includes an accounting routine and has the ability to remember that node 18 is inferior to node 19 as a location. This procedure is continued until no better location can be found.

FIGURE 5

NETWORK SEGMENT USED TO DESCRIBE THE OPERATION OF

THE TOTAL TRAVEL REDUCTION HEURISTIC



If there are several facilities in the system (e.g., a 5-facility problem), the heuristic technique begins with the first node on a given list of nodes and cycles once through the process of evaluating the nodes adjacent to it. If an improvement can be found, this facility is moved. However, instead of attempting to reduce total travel through additional searches around this new location while keeping the other facility locations fixed, the heuristic selects the next node on the list and searches the space around it. This procedure is continued until all of the initial facility locations have been examined once. This describes the first complete pass of the evaluation process. The next pass involves repeating the evaluation process for each of the facility nodes, again searching around each facility node only once. This process is repeated until no further reduction in total travel can be found by moving any facility to one of its neighboring nodes. The process is then stopped and a display of the best solution found is presented to the analyst.

4.2 The Longest Trip Reduction Heuristic (LTR)

A second heuristic, called LTR, was developed to search for ways to minimize the length of the longest trip from a facility to a demand node. The heuristic is simple and transparent and it employs a search technique similar to that used in the total travel reduction heuristic.

The analyst selects an initial facility location pattern and calls for the heuristic search to be applied to it. The heuristic quickly determines which facility (if multiple facilities are involved) has the furthest node assigned to it (i.e., longest trip). It then moves that facility one node along the minimum path toward the furthest node. In other words, the heuristic moves the facility so as to shorten the length of the longest trip in the entire system. Then, a recalculation of assignments occurs, and the facility which has the furthest node assigned to it is again moved according to this rule. The process is continued until no further reduction can be made in the length of the longest trip between a facility node and its furthest assigned demand node.

Clearly, these two heuristics operate on different aspects of the location-allocation problem. Moreover, the analyst can "play" one against the other in that he can call one up and let it run until it stalls and then call the other up and let it attempt to find some further improvement. This process can be continued until neither heuristic is able to make any further progress. Any solution which can stall both heuristics is probably a very good solution. However, this outcome cannot be guaranteed as it is always possible that both heuristics can be stalled on a poor solution as well.

4.3 Results of Experiments with the Heuristic Search Techniques

Some experimental work has been done which was designed to (1) assess the relative performance of these two heuristics and (2) to find the best possible solution to the test problem for use as a reference in the human intuition experiments discussed in Section 5. In this experimental work, three location patterns were selected, each of which has a quite different total travel-longest trip characteristic. These starting points are labeled A, B and C in Figures 6 and 7. Each of these location patterns were used as the starting points for two types of test runs.

In the first set of three runs (from positions A, B and C on Figures 6 and 7) a TTR-LTR sequence was used (see Figure 6). In the second set of three runs (see Figure 7) this sequence was reversed (i.e., LTR-TTR). In both cases, the first heuristic in the sequence was allowed to run until it stalled and then the other heuristic was called up and started on this stall point. The heuristics were applied sequentially until a performance position (i.e., location solution) was found which neither heuristic could improve. In most cases, an actual stall point was not found. Instead the two heuristics tended to oscillate back and forth between two points (location solutions). Thus, they actually stalled on a track segment rather than on a particular point.

FIGURE 6

TRACKS PRODUCED BY THE TTR-LTR SEQUENCE OF THE HEURISTIC TECHNIQUES

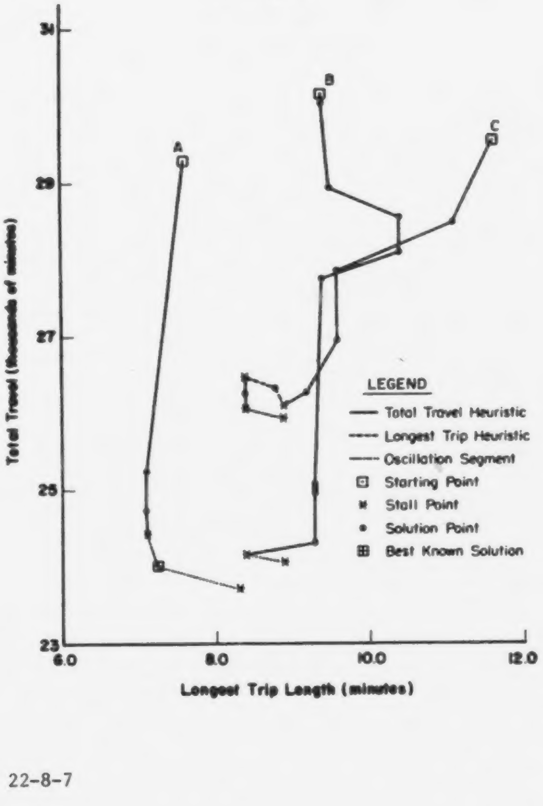
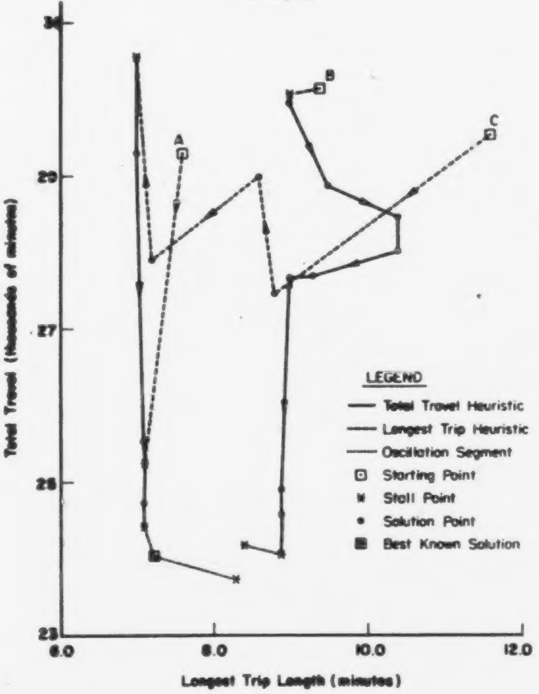


FIGURE 7

TRACKS PRODUCED BY THE LTR-TTR SEQUENCE OF THE HEURISTIC TECHNIQUES



None of these six runs produced a better solution than was found in the initial exploratory investigations that took place prior to the formulation and implementation of the heuristics. Moreover, only two of the six runs "found" this previously known "best" solution. The others stalled on solutions that were not as good as this solution. This finding suggests that if we were to rely entirely on the heuristics to find good solutions, we would certainly need to make several runs from various starting positions in order to be reasonably sure that the best solution found is, in fact, one of the better ones available. These experimental results also indicate that neither heuristic would have "found" the best known solution by itself. It was only when they were jointly used that this occurred and then in only one-third of the runs tried.

The tracks in Figure 6 and 7 show that both heuristics are reasonably efficient in that they both drive the total travel and longest trip values down quite rapidly. One cannot determine from these few results whether one of these heuristics is significantly more efficient than the other. However, it can be noted that the greatest reductions were made by the TTR heuristic and that these reductions were typically much greater than those produced by the LTR heuristic (see Figures 6 and 7). Much more experimentation with these heuristics in a variety of situations will be required before a more general assessment of their potential utility can be made. It is also possible that if the search procedures incorporated in these two heuristic techniques can be integrated into a single, more comprehensive search procedure, better results than those produced by the sequential applications described here might be obtained.

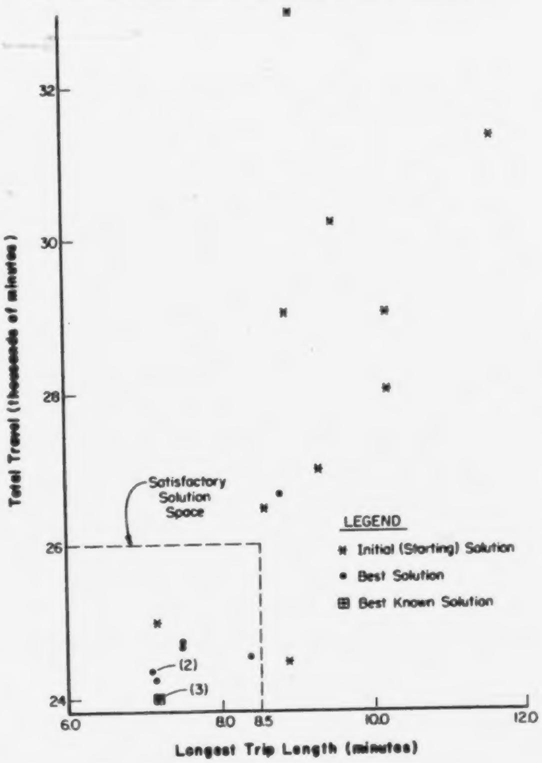
5. Design and Implementation of a Human Intuitive Search Experiment

As discussed in the previous section, it presently appears that the most effective approach to solving large location-allocation problems will utilize the human analyst (1) to select good starting solutions and (2) to guide the application of one or more computer-based heuristic search techniques. If this is true, then we need to learn more about how to select good starting solutions and about how to design powerful heuristic search techniques. The experiment discussed in this section has been designed with both of these questions in mind but has been limited in scope and addressed to only one question: Given a variety of quite intelligent people, how many of them can intuitively solve the test problem with the LOCATOR System? To answer this question, 9 graduate students and 1 undergraduate student at the University of Washington were selected and given some basic information in written and graphic form about the problem and the operation of the LOCATOR System. Then, each assumed the role of the analyst and attempted to find a satisfactory solution to the problem. The experience obtained from this experiment is now summarized.

A plot of the initial and "best" solutions obtained by the students is shown in Figure 8. In this experiment, a satisfactory solution was defined as any solution which would plot within the area defined by a trip length of 8.5 minutes and a total travel figure of 26,000 minutes (See Figure 8). Each student was told that he should attempt to find a solution that has performance measures which are equal to or less than these two figures. As can be seen in Figure 8, nine of the ten students were able to find a satisfactory solution to this problem. Furthermore, three of these "best" solutions were identical to the "best known" solution that was derived from the rather extensive search which utilized the two heuristic search techniques in Section 3 and six others are very close to it. Two examples of the actual paths followed by the students in moving from their initial solutions to their final solution are shown in Figure 9. Figure 9 shows the tracks made by the most and least effective problems-solvers in the group. "Effectiveness" is defined here as the selection of a good starting point followed by rapid and direct progress toward the best known solution. The most effective problem-solver has had considerable coursework in the field of architecture which gave him experience in solving design problems. Figure 9 also shows the track made by the least effective problem-solver who was unable to find a satisfactory solution. This person's background was in the field of political science and he had no previous experience with this type of problem.

FIGURE 8

INITIAL AND BEST SOLUTION OBTAINED BY PARTICIPANTS



In all cases, none of the students had had any previous experience in working interactively in a man-computer environment. Naturally, consid-

FIGURE 9

THE TRACKS OF ONE OF THE MOST AND THE LEAST SUCCESSFUL PROBLEM-SOLVERS

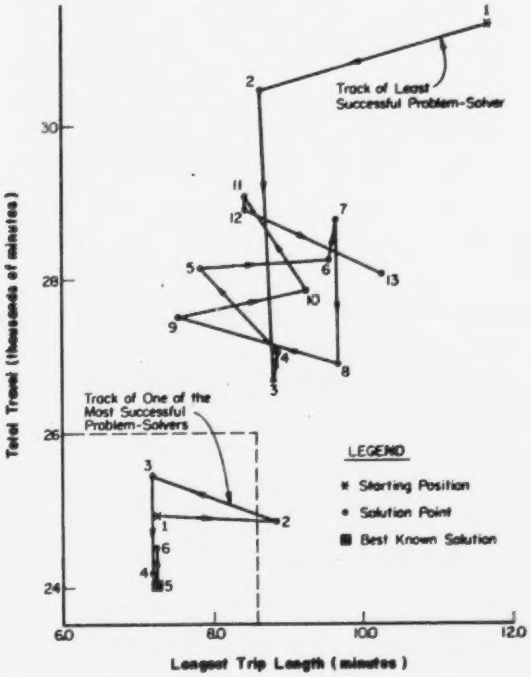
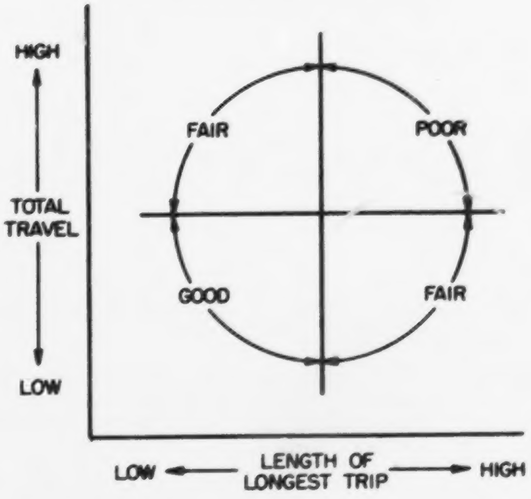


FIGURE 10

CLASSIFICATION OF TRACK ELEMENTS ACCORDING TO THEIR DIRECTIONAL CHARACTERISTICS



erable learning took place. Most of the students initially tried to move more than one terminal at a time. They quickly learned that they did not progress very well doing this as they were unable to determine which moves were "good" and which were "bad." Most of them then reverted to a "one at a time" strategy which enabled them to determine the effect of a particular type of change on the performance measures of the system. Once they developed some understanding of "how the system works," they were generally able to make steady progress toward the best known solution.

A partial analysis of the paths or tracks of each person can be made in terms of their directional characteristics. Figure 10 shows how each move can be classified into one of three categories; good, fair and poor. It is assumed that, in general, every participant was trying to make a good move (guess) so as to progress toward the objectives. An analysis of all of the tracks shows that of the 92 moves made by the participants, 40.2 percent can be classified as good, 42.4 percent as fair and only 17.4 percent as poor. While this result cannot be considered to be conclusive in any sense, it does indicate that reasonably intelligent people may well be able to find satisfactory solutions to problems of this type intuitively with the aid of the LOCATOR System.

In spatial terms, the best solutions obtained by the students were highly similar. Three of the solutions were identical (i.e., the five locations selected were exactly the same). Seven of the solutions had four of the five locations in common and differed in the location of the other terminal. Eight of the solutions had three locations in common and all ten had two locations in common.

As indicated in Figure 8, three of the students found a solution that was identical to the best solution found with the aid of the heuristics described in Section 3. The heuristics were applied using these best student solutions as starting points, but they produced no further improvement. In our judgment, it is highly probable that this solution is very "near" to the optimal solution to this problem.

6. Conclusions

To date, the LOCATOR System has been found to be a flexible and useful tool for (1) finding good solutions to a simplified version of the general location-allocation problem, (2) helping a wide variety of people to understand the nature of problems of this type (i.e., the effect of various types of changes on service areas and system performance measures) and (3) assisting the development of effective computer-based heuristic search techniques.

The fact that the heuristic search techniques produced good results only when used together is probably significant as is the fact that they produced inferior results in four of the six test runs conducted. These results suggest that the human not only has a role in selecting a starting point for a heuristic search but that he can probably find ways to help them proceed when they are stalled.

The human participants performed very well on this simple problem. In most cases, they performed as well or better than the heuristics and their record (3 of 10) in terms of finding the best known solution is only slightly worse than that of the heuristics (2 of 6).

Future experimental work will be focused on much larger and complex problems involving more than two objectives, a large and complex network and demand pattern and a larger number of facilities to be located. The attempt will be to determine how capable human intuition is in solving large complex problems, both with and without the aid of computer-based heuristic search techniques.

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COMPROSPACE: INTERACTIVE COMPUTER GRAPHICS IN THE REAL WORLD

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Abstract

COMPROSPACE is a new concept of interactive graphics manipulation. The program allows the user to interactively create drawings using different kinds of lines and standard graphic elements. The user can also manipulate drawings with functions such as scaling, calculation, repeat, rotate, move and delete etc. The program is equipped with full storage and retrieval capabilities.

Section 1: Introduction

COMPROSPACE is a new concept, one of a family of problem solving tools in the ARK/TWO system, specially developed for the architect and layout planner by the firm of Perry, Dean & Stewart, Architect and Planners, of Boston, Massachusetts.

The concept is that of, a triangle with a computer and associated peripheral devices at one side, a program and data in a data bank at the other side, and the architect at the apex of the triangle interacting with the data and creating, evaluating, and recording his own new ideas.

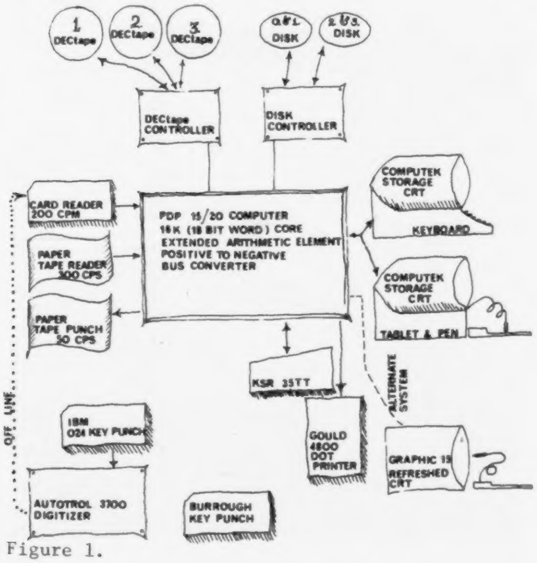

1. DECtape
2. DECtape
3. DECtape
0 & 1 DISK
2 & 3 DISK
DECtape CONTROLLER
DISK CONTROLLER
CARD READER 200 CPM
PAPER TAPE READER 300 CPS
PAPER TAPE PUNCH 50 CPS
PDP 15/20 COMPUTER
16K (18 BIT WORD) CORE
EXTENDED ARITHMETIC ELEMENT
POSITIVE TO NEGATIVE
BUS CONVERTER
COMPUTEK STORAGE CRT
KEYBOARD
COMPUTEK STORAGE CRT
TABLET & PEN
KSR 35TT
ALTERNATE SYSTEM
GOULD 4800 DOT PRINTER
GRAPHIC 15 REFRESHED CRT
OFF LINE
IBM 024 KEY PUNCH
AUTOTROL 3700 DIGITIZER
BURROUGH KEY PUNCH

Figure 1.

The ARK/TWO system is made up of a specially selected hardware group and a series of computer programs. Shown below is the listing of the various devices making up the hardware group. (Figure 1.)

PDP 15/20 Computer System

2-	MM 15-A	2- 4K Core Memory
2-	MK 15-A	2- 4K Core Memory (Total 16K)
	KE 15	Extended Arithmetic Element
	TC02D	DEC Tape Control
3-	TU55	DEC Tape Transport
	PC 15	Paper Tape Reader and Punch
	DW 15-A	Positive to Negative Bus Converter
	RF 15	DEC Disk Control
2-	RS 09	Disk
	CR03B	Card Reader
	KSR-35	Teletype

PDP 15 Display System

VT15	Graphic Processor
VT04	Scope
VL04	Light Pen
VV15	Arbitrary Vector
VW01	Writing Tablet and Pen
LK35	Keyboard

Computek Display System

2- Series 400/15	Cathode Ray Tubes which include: -Vector Generator -Character Generator -Keyboard Input Module -Tablet Input Module

Gould Printer

Series 4800	Electrostatic Printer which includes: -Transport Unit -Electronic Unit -Varatek Special Interface

Autotrol Digitizer

Model 3700	Data Control and Display Console
Model 3929	X - Y Recorder and Table
2- Model 3927	Easy Reach Panels
IBM 024	Key Punch

In this particular system the PDP-15/20, a 16-K core mass-storage-oriented system is used for the design and research diciplines where real-time data acquisition and control tasks are combined with program development and testing. Program development, debugging, and modification are all handled under monitor control. Unique real-time input/output routines are integrated into the system monitor to accelerate set-up and recovery. The distinct feature of this system is in its DECtape. A single pocket-sized reel of tape 3 1/2 inches in diameter can accommodate up to 150,000 words of data, the maximum access rate of which is 5,000 words per second. (Figure 2.)

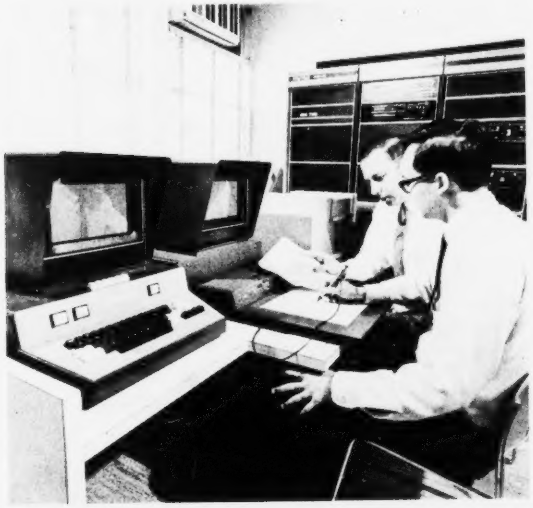


Figure 2.

The Computek 400/15 Cathode Ray Tube (CRT) display terminals compose a graphic and alphanumeric man-manchine communication system. It includes display-labeled function keys for flexible man-machine interaction, a synchronous operation for data speed up to 2000 characters for second, and two storage CRT display modules that maintain over 800,000 points of information on the display, enough to literally tone the entire screen with lines.

The Computek Graphic Tablet is an accurate, high-speed graphical input device. It converts pen position into digital form while the pen is writing, drawing or pointing on the tablet surface. The tablet may be used as a scratch pad, as a graphic pointer, for tracing drawings and for instruction and greater interaction in Computer-Aided Design.

The Tablet's etched pattern and electromagnetic detection technique make possible the digital sensing and coding of over a million points on the 11 x 11 inch writing surface with an accuracy and linearity of ± 0.05%. Six function keys, a proximity detector and a pen-pressure switch permit the entry of z-axis data, or other program-interpretable functions.

The PDP 15 Display System is aimed to deal with interactive computer graphics which require refreshed CRT capabilities. It is well suited for simulation of perspectives and traffic flows etc.

The Gould 4800 printer applies an electrostatic printing technique that composes optimally the electric charge deposition system, the liquid toning system, the paper system, (including the special paper itself) and the associated electronic circuitry. Refinement of this combined system has resulted in the reliable, quite, high speed performance of the printer and in the high quality of the hard copy produced.

Briefly stated, the special paper is passed over a writing head which contains a row of charging styli. When addressed, the styli deposit an electric charge directly onto the paper surface. As the 8 1/2 inch wide paper advances, the charged areas encounter the toning head which floods the paper surface with liquid toner. Black toner particles in the liquid are attracted to the charged areas and affix themselves to the paper. The excess liquid is then removed from the paper surface and returned to the toner reservoir. The hard copy that has thus been produced (at "page per second rates") then emerges from the printer, dry, and ready to be used as a record which may be kept for years without deterioration.

Figure 3.

The Auto-trol Model 3700 Series All-Solid State Digitizer with its associated remote control data entry units provides an extremely versatile digital readout system, designed specifically for the full range of data reduction applications. (Figure 3.)

Matrix of Computer Programs and Tasks in an Architectural Design Process		PREDESIGN			PROGRAMMING				SCHEMATIC DES				DES DEVELOPMENT					WORKING DRGS				SPECS BID			CONSTRUCT		
		Checking similar projects	Estimate schedules	Estimate manpower needs	Review similar room types	Model area program	Work out relationships	Establish parameters	Develop plan layouts	3-dimensional studies	Establish cost goals	Start outline spec	Review room details	Mech studies	3-dimensional studies	Revise cost goals	Redo outline specs	Plans sections elev.	Mech. studies	Construction network	Estimate	Edit master spec	Print specifications	Cost review	Construction monitor	Cost monitor	Shop drawing monitor
DRAW	COMPROSPACE	o			o			o	o			o	o					o					o	o			
	COMPROVIEW							o		o				o	o				o								
COLLECT/SORT	COMPROGRAPH	o			o	o			o			o	o					o				o					
	COMPROPLAN								o				o					o									
MANIPULATE/MANAGE	COMPROWORK		o	o					o				o					o				o		o			
	COMPROMAN			o				o				o					o				o		o	o	o		
	COMPRONET		o					o												o			o				
	COMPROAREA	o			o	o					o		o			o					o			o	o	o	
	COMPROCOST	o									o					o					o	o		o		o	
	COMPROSPEC	o						o			o	o				o	o			o	o	o	o	o			
SPECIAL	COMPROSTAIR									o																	
	COMPROLINK							o						o					o								o
	COMPROPARK	o									o					o											
	COMPROSIGN																	o									
	COMPROGRAM	o			o	o		o																			

Figure 4.

Depending upon the particular scaling requirements X-Y, X-Z and X-Y-Z coordinates from the drawings are scaled and converted into a precisely proportional count rate representing the measured unit of travel. In turn, the accumulated pulse rate is counted and the measured coordinates are displayed on the front panel of the Data Control and Display Console. Subsequently, on command from the operator, the measured coordinates, along with constant and identification data, are transferred to the Card Punch for recording in direct computer-entry format.

COMPROSPACE is the basic software graphic package that ties together these elements into an overall software system. (Figure 4.) It is concerned with floor plans, elevations, working drawing details and other two-dimensional graphics. The program provides an

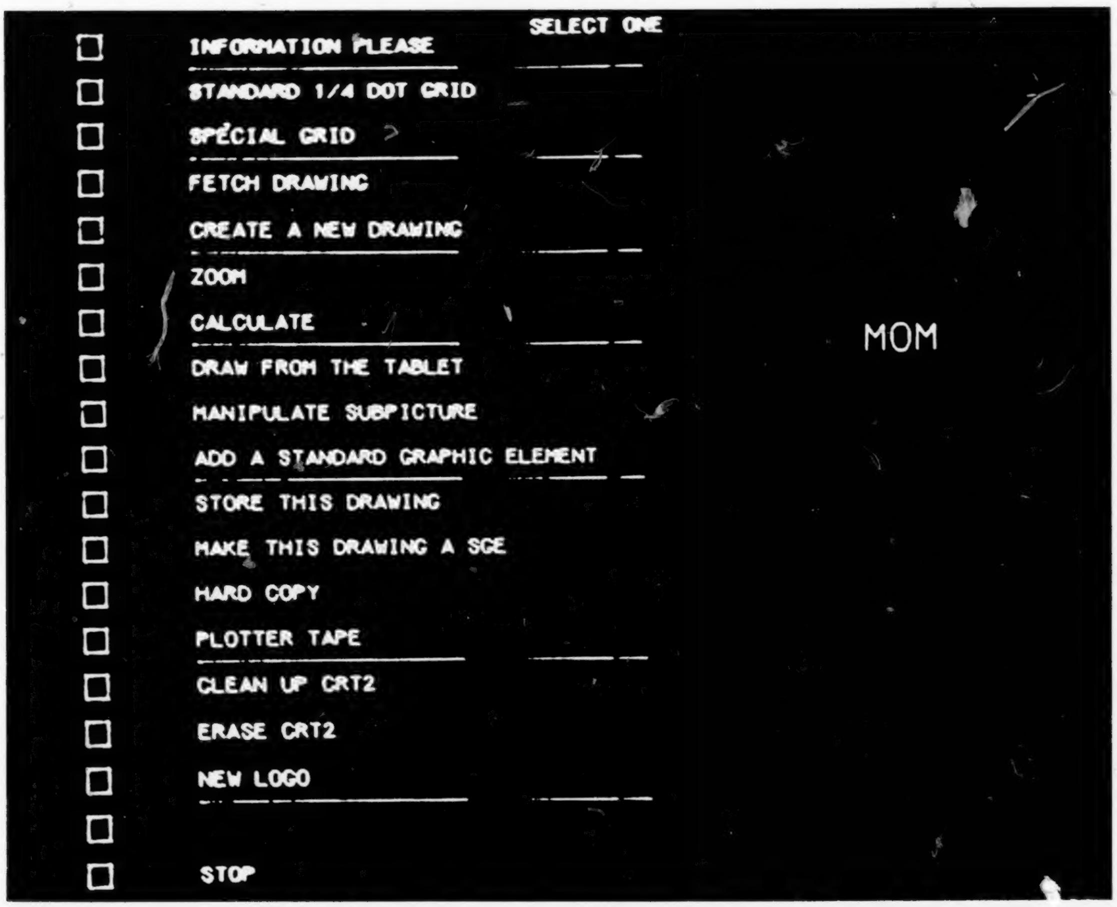

SELECT ONE
☐ INFORMATION PLEASE
☐ STANDARD 1/4 DOT GRID
☐ SPECIAL GRID
☐ FETCH DRAWING
☐ CREATE A NEW DRAWING
☐ ZOOM
☐ CALCULATE
☐ DRAW FROM THE TABLET
☐ MANIPULATE SUBPICTURE
☐ ADD A STANDARD GRAPHIC ELEMENT
☐ STORE THIS DRAWING
☐ MAKE THIS DRAWING A SGE
☐ HARD COPY
☐ PLOTTER TAPE
☐ CLEAN UP CRT2
☐ ERASE CRT2
☐ NEW LOGO
☐
☐ STOP
MOM

Figure 5.

inventory of standard graphic elements (SGE) such as different furniture, functional units, detail segments and "zipatones", which can be incorporated in a given job. These elements may be manipulated (moved, rotated, repeated or deleted) at will by the individual to afford complete flexibility of design including a wide choice of scales. The user calls on the program to provide the graphic data on the display screen (the Cathode Ray Tube). He, in turn, is creating a total drawing that appears on this screen following his movement of the drawing stylus on the surface of the magnetic tablet in front of the display screen. In addition, the user is given textual alternatives in the form of a menu on the adjacent display screen such as "fetch drawing", "add a standard graphic element", etc. which are the different commands that the computer will execute according to the user's selection. Hard copy output of the graphics is available from the automatic printer incorporated into the system. (Figure 5.)

There are several basic advantages of COMPROSPACE. One is the feedback and interactive between program and user which accelerates the process of design. In addition the designer can be assured that he is comparing a drawing made up of accurate parts, and thirdly he can change scale of the drawing at any time to refresh his memory of the overview of the problem by zooming out or to work at highly intricate detail by zooming in.

Section 2: Operation

Since natural interaction between the professional architect and the computer was a basic generator of the ARK/TWO system, it is not a surprising discovery to learn that the training period, for a newcomer to the computer field, requires about one-half hour instruction. To become proficient he need only spend an hour or so of trial and error solo time at the ARK/TWO design station and he is ready to teach others.

Beginning the task involves a few simple steps to activate the PDP-15/20 computer at the start of the work day. The designer turns on the computer and reads in to the computer a paper tape which will put the computer control to the "monitor". He then types in two lines of coded information through the teletype. The computer is now in an "execute" mode and asks questions on the screen according to the programmed instructions.

Before being able to "fetch a drawing", "add a SGE" or "store this drawing" etc, he must mount three tapes on the face of the computer. Usually tape one is reserved for the record tape of his last work on the project. Tape two stores standard graphic elements such as furniture, fixtures, window and wall details, graphic formats and the like. Tape three can be used as either a scratch tape, a numerical data tape, a complete hospital area program or a storage for new design developments which the designer may keep separate from the last set.

Using the computer workstation is a simple operation. First the designer logs in by entering through the keyboard the job name, his initials and the date (so that we can properly assign time charges to the various projects). This information, along with the drawing number scale appears on every drawing thereafter. He then selects the appropriate command displayed on the left screen of the workstation. When we refer to "selection" we mean that the designer slides the tip of the special pencil over the surface of the electronic tablet in front of him while watching the cursor (marker) which moves correspondingly across the face of the screen in front of him. When the cursor is positioned anywhere inside of a 1/4" box displayed next to the selected command item on the face of the screen he presses the pencil against the tablet surface. An "x" appears in the box to confirm that selection has been made and the computer proceeds to execute the task. The same procedure is used for all selection requirements. There is an absolute minimum of typing for other than direct text-entering tasks.

The first selection list or menu which appears is the Master Operational Menu called MOM. It is the grouping through which we select all the subsets of drawings, calculating, zoning and so forth. Each subset is represented by a new name and some have further subsets each with a more detailed menu. Every subset has an escape back to MOM if we get into trouble. The first task is to either "fetch a drawing" from the record tape which needs to be worked over, or to select the box labeled "Create a New Drawing". Since the computer will not know what to do with the data which does not apply either to an already named drawing or a newly named data file, it is programmed not to proceed unless one of these two selections is made first. Once the title of the new or existing drawing is entered we can proceed. Finding a drawing on tape and displaying it on the screen takes about 15 seconds.

Every drawing is divided into a set of subpictures. When we want to edit a drawing which we have called up from a tape we select the square in MOM that is labeled "Manipulate a Subpicture". Every subpicture is immediately identified by a square which appears in the lower left hand corner of a subpicture.(Figure 6.)

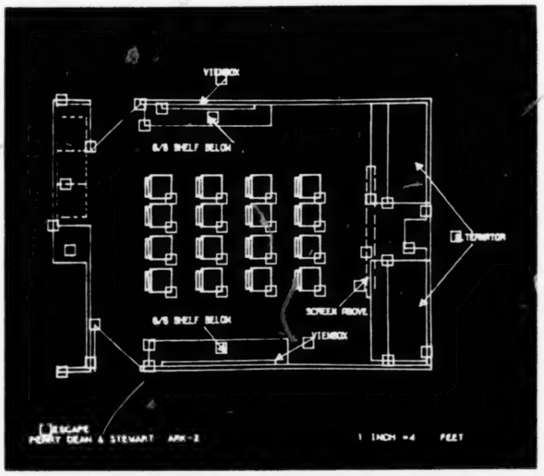


Figure 6.

A list of possible commands is then presented for our selection by which we can manipulate any of the subpictures, move, delete, rotate, repart or in combination. (Figure 7.) We select one and are asked to locate the subpicture which we want to manipulate. We move the cursor which has been automatically transferred from the menu on CRT1 to the drawing on CRT2 so that it falls inside the square of the subpicture origin and we press on the pen. An x appears in the square. In the case of moving a subpicture, we move the cursor to the new location on CRT2 and press again. In less than two seconds, the subpicture has been moved to its new location. (Figure 8.)

In a room layout, for instance, we may wish to move a wall 9". We use the subpicture command "move" and the wall can be relocated. The designer can erase a toilet arrangement and draw in a new one. He can rotate a furniture grouping 90°, 7° or 353°. He can repeat a tone,

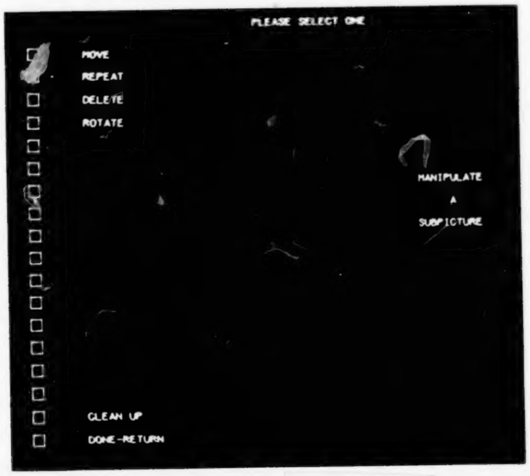

PLEASE SELECT ONE
☐ MOVE
☐ REPEAT
☐ DELETE
☐ ROTATE
MANIPULATE A SUBPICTURE
☐ CLEAN UP
☐ DONE-RETURN

Figure 7.

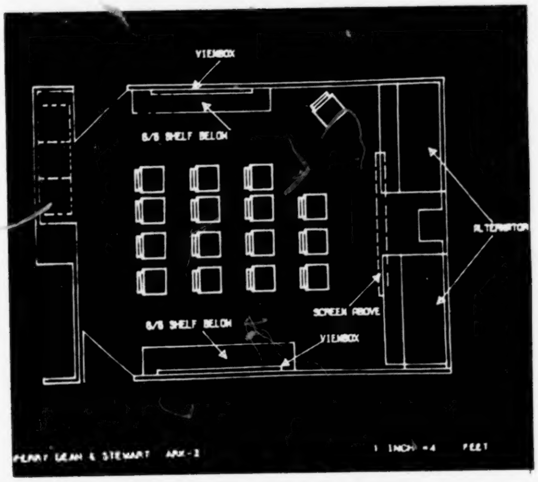

VIEWBOX
8/8 SHELF BELOW
ALTERNATOR
SCREEN ABOVE
8/8 SHELF BELOW
VIEWBOX
PERRY DEAN & STEWART ARX-1
1 INCH =4 FEET

Figure 8.

detail or a desk arrangement once or one-hundred times.

If the designer elects to "create a new drawing" he has the option of overlaying a grid of dots or lines over the second screen (CRT2). This is a grid which is visible only to the designer and not recorded by the computer as part of the drawing. It is for his reference only. He can select a standard grid which is 1/4" dot matrix. This has a round-off factor of 1/16" and is not able to accept locations of less than this dimension in either direction. The designer can also create his own special grid of dots or lines at any vertical spacing, any horizontal spacing, perpendicular or skew to any specified degree, with any round-off factor down to 1/64".

To create new lines the designer selects the command "Draw from Tablet" from MOM. This generates a new menu which has selections such as straight line, vertical-horizontal line, circle, arc, 90° arc, rectangles, full dimension set, arrows and text. (Figure 9.) A normal drawing routine for a room might be as follows. (The procedure for wall sections, handrail details or contoured site drawings essentially is the same). Establish drawing title and scale. The scale will be important later in the enlarging or reducing of the drawing. With the guidance of a dot grid and by using vertical-horizontal line, he can lay in the basic room skeleton, (Figure 10.) use the rectangle command to insert counters and window sills, select arcs for doors swings, back to line for folding doors and any special details. (Figure 11.) In all of these we have the option of three line weights and dashed line by using function switches on the tablet itself so that we can change line quality without going back to the menu. If we make a mistake a special button erases the last entry. By backing through the entries in order, we can erase any number of lines or points.

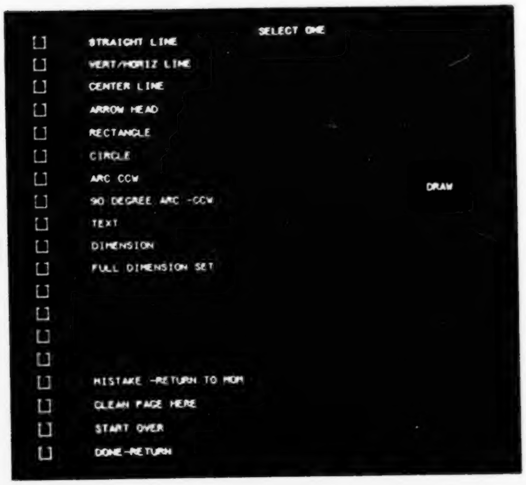

SELECT ONE
☐ STRAIGHT LINE
☐ VERT/HORIZ LINE
☐ CENTER LINE
☐ ARROW HEAD
☐ RECTANGLE
☐ CIRCLE
☐ ARC CCW
☐ 90 DEGREE ARC -CCW
☐ TEXT
☐ DIMENSION
☐ FULL DIMENSION SET
DRAW
☐ MISTAKE -RETURN TO MOM
☐ CLEAN PAGE HERE
☐ START OVER
☐ DONE-RETURN

Figure 9.

If we want to add furniture to the room, add standard details to a wall section, or standard format to a drawing we return to MOM and select a command, "Add a Standard Graphic Element".

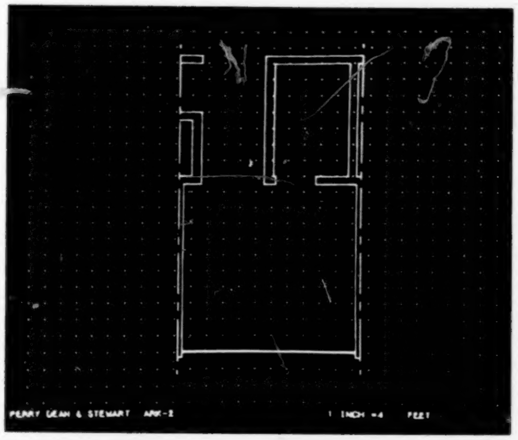
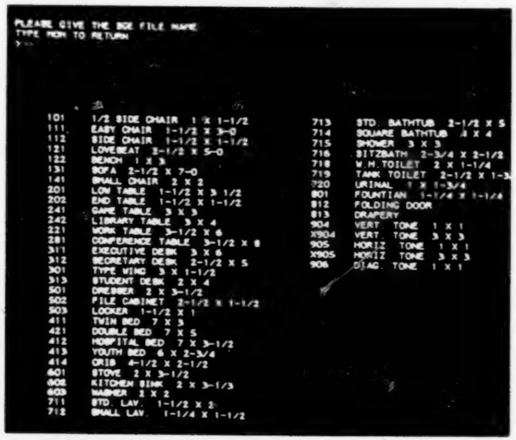


Figure 10.



```
PLEASE GIVE THE SGE FILE NAME
TYPE MON TO RETURN
>

101   1/2 SIDE CHAIR  1 X 1-1/2            713   STD. BATHTUB  2-1/2 X 5
111   EASY CHAIR  1-1/2 X 3-0              714   SQUARE BATHTUB  4 X 4
112   SIDE CHAIR  1-1/2 X 1-1/2            715   SHOWER  3 X 3
121   LOVESEAT  2-1/2 X 5-0                716   SITZBATH  2-3/4 X 2-1/2
122   BENCH  1 X 3                         718   W.H.TOILET  2 X 1-1/4
131   SOFA  2-1/2 X 7-0                    719   TANK TOILET  2-1/2 X 1-3
141   SMALL CHAIR  2 X 2                   720   URINAL  1 X 1-3/4
201   LOW TABLE  1-1/2 X 3 1/2             801   FOUNTIAN  1-1/4 X 1-1/4
202   END TABLE  1-1/2 X 1-1/2             812   FOLDING DOOR
241   GAME TABLE  3 X 3                    813   DRAPERY
242   LIBRARY TABLE  3 X 4                 904   VERT. TONE  1 X 1
221   WORK TABLE  3-1/2 X 6                X904  VERT. TONE  3 X 3
281   CONFERENCE TABLE  3-1/2 X 8          905   HORIZ. TONE  1 X 1
311   EXECUTIVE DESK  3 X 6                X905  HORIZ. TONE  3 X 3
312   SECRETARY DESK  2-1/2 X 5            906   DIAG. TONE  1 X 1
301   TYPE WING  3 X 1-1/2
313   STUDENT DESK  2 X 4
501   DRESSER  2 X 3-1/2
502   FILE CABINET  2-1/2 X 1-1/2
503   LOCKER  1-1/2 X 1
411   TWIN BED  7 X 3
421   DOUBLE BED  7 X 5
412   HOSPITAL BED  7 X 3-1/2
413   YOUTH BED  6 X 2-3/4
414   CRIB  4-1/2 X 2-1/2
601   STOVE  2 X 3-1/2
602   KITCHEN SINK  2 X 3-1/3
603   WASHER  2 X 2
711   STD. LAV.  1-1/2 X 2
712   SMALL LAV.  1-1/4 X 1-1/2
```

Figure 12.

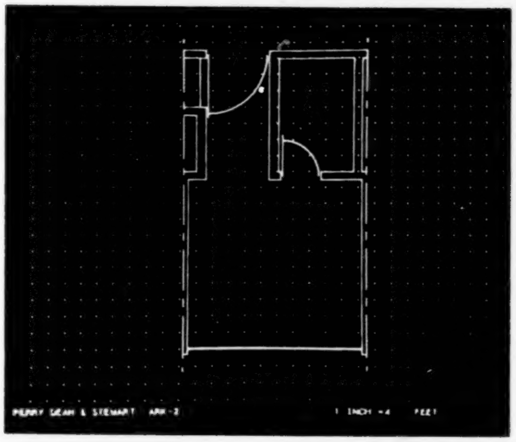


Figure 11.

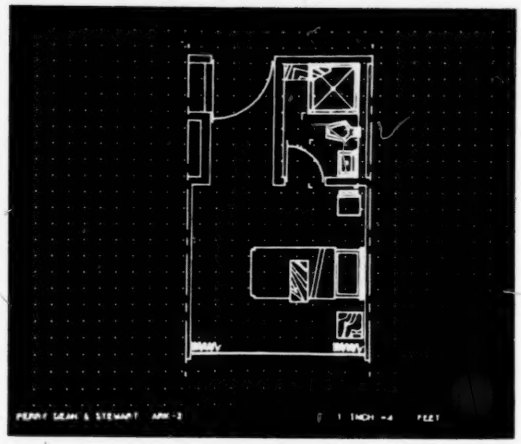


Figure 13.

(Figure 12.) We then select the particular SGE from a list of those on the previously mounted tape and are then asked whether we want it oriented either 90°, 180°, 270° or a special number of degrees which we enter through the keyboard. We also have the option of entering any number of the same SGE at one time, which is a great time saver in locating trees on a site plan, or chairs in an auditorium or bricks in a wall detail. We locate the origin point of the selected SGEs and they are generated in the drawing. (Figure 13.) We are then asked to confirm that they are located correctly or to change them until they are correct, after which they become a part of the drawing. We can, of course, return later to omit change or add details as different or additional information becomes available.

Notes to the drawing can be added by typing in text and locating arrows to the parts labeled, all from the same "Draw from the Tablet" command menu.

When we wish to go on to another task we can store the drawing on tape under the original title, or, if we wish to keep both the original and an edited drawing, we can change the name of the new drawing. If we do not, this drawing will automatically replace the drawing of similar name in the tape, which may be desirable. At the same time, we can request hard copy of the drawing or text from the Gould printer at the rate of one 8 1/2" x 11" page in less than two seconds. For larger drawings we create a punched paper tape that is used to run a XY plotter off-line.

We can also take advantage of two special features of the program that give us the options of enlarging, or reducing the drawing, and moving the drawing left, right, up or down at the same or any other scale. While the face of the Cathode Ray Tube that we are actually looking at measures 8" x 10", "Zoom" encourages us to think of our projects at immense, total scale, even full size. By zooming out like a rising helicopter we can see and draw the entire project in simplified terms on the 8" x 10" screen. (Figure 14.) By zooming back into the drawing we can work on it at middle scale, section by section, and by zooming into the drawing further we can design ever the smallest details. (Figure 15.) The screen becomes then a window which we can move back and forth and up and down across the surface of the drawing which, in fact, can be conceived as being as large as the final building itself. All the data entered on one scale is available at any other scale, all calculated and displayed with speed and accuracy by the computer. A three inch bolt entered at full size is still there holding two pieces of metal together when the drawing is displayed at the scale of 1/32" = 1'-0" and can be zoomed up to 3/4" scale, looked at, changed or repeated at any time with ease. We are not sure what effect this capability may eventually have on the overall design process, but we can already see how it changes a designer's attitudes about the potentials of design involvement in very large and complex buildings.

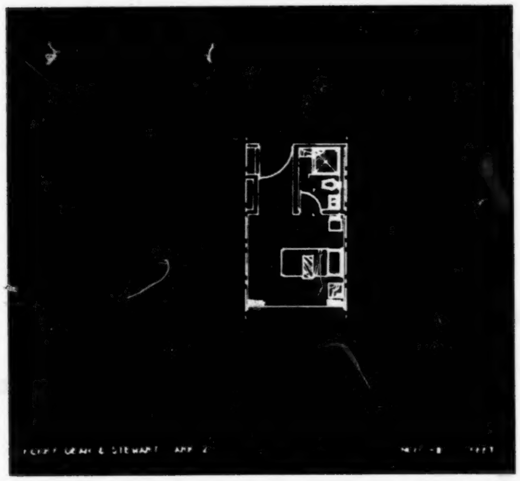


Figure 14.

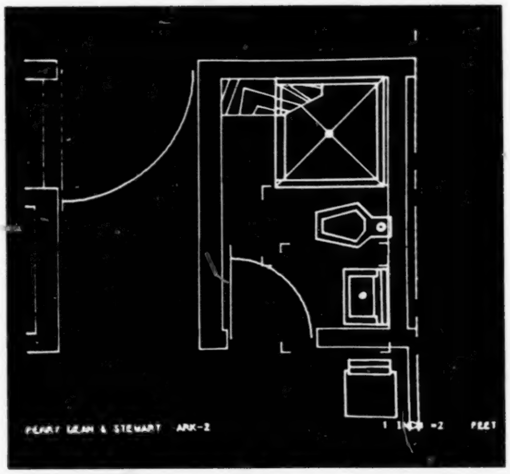


Figure 15.

Another feature of COMPROSPACE is "calculate" which is described as follows: with a pen and tablet we identify the end points of a series of lines, and its dimensions are immediately identified taking into account the scale at which the drawing is displayed. (Figure 16.)

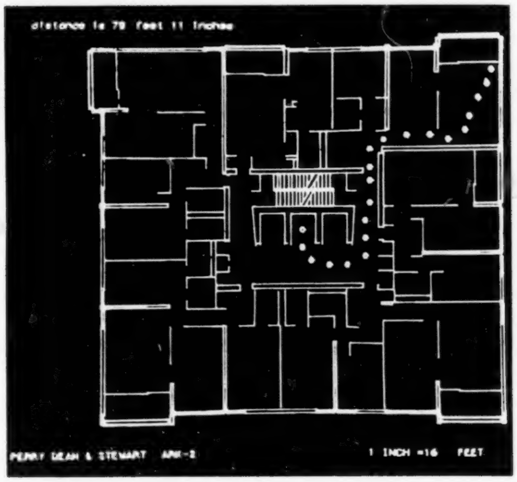


Figure 16.

Identifying all the corners of a space or objects produces a similar instantaneous calculation of the area, even though it may be complex non-rectilinear configuration with twenty or more corners and with enclosed areas which must be deducted. (Figure 17.) However by making the linear dimension cumulative we can trace the path length for circulation routes, and by adding vertical dimension to areas we get cube calculations. By adding a vertical dimension to a series of lines we can get the areas of vertical planes either singly or cummluatively.

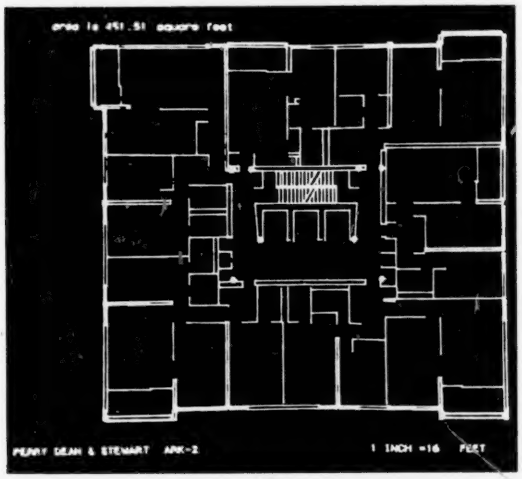


Figure 17.

The designer is now able to layout sign graphics with automatic spacing and proportion, design stairs that comply with code requirements and show them in full detail. A big job made easy is in the layout of auditoria seating showing sight lines and individual seats in place. In the realm of trouble shooting, the COMPROSPACE program compares actual areas with program areas to uncover potential problems. Another task is to compare travel distance with desirable norms. Mapping is accomplished with "zepatone" patterns for demographic studies.

Section 3: Technicality

COMPROSPACE is a graphics software package which represents a response to the needs of almost anyone with a graphics application, from architectural design or printed circuit layout. Written in Fortran IV computer language, COMPROSPACE is compatible with most computer systems. Its modular design allows the user to choose those parts of the total system particularly suited to his individual needs, and allows interfacing of a wide range of graphic input/output devices with a minimal amount of reprogramming.

Note that COMPROSPACE is an "open-ended" computer program. It is modulized to such an extent that additional subroutines corresponding to the particular user commands can be incorporated efficiently.

The program is composed of a series of subroutines which perform specific functions and a control program which allows the user to select the operation he wishes and performs the appropriate subroutine routings. A list or menu of possible actions is displayed on the CRT screen. The user positions the cursor by the desired command and signals the computer. The control program then calls the appropriate set of subroutines to fulfill the command. If necessary, one list can generate another more detailed list from which the user may select an appropriate command.

The COMPROSPACE program is divided into the User Interface subroutine and the Graphic Processor subroutine. Both of these are served by different levels of service routines.

With one exception, the programs in the User Interface handles only the command display and control for the graphic operations. It is assumed that one CRT (CRT1) is available for the display of the information while the graphics are presented on a second (or multiple) CRT(s). Each graphic operation (ZOOM, FETCH, DRAW, STORE, etc.) is handled by a specific subroutine. A single routine (MOM) allows the user to select the operation and does the subroutine routing. Some direct jumps, between operations, are possible (plotter tape to Zoom.)

Each control subroutine produces calls to the command CRT (CRT1) and receives information from the graphic tablet (X, Y switcher) and keyboard (ASCII - alphanumerics). Although numerous subroutines are usually involved in this transfer, all information between the graphic station and the program passes through one of two routines (IN, OUT) which performs the input-output transfers. The transfer could be intercepted at a higher level where routines handle ASCII in and ASCII out, graphic tablet data in, screen switch command out, CRT draw commands out, etc.

Requests for graphic output (on CRT2, PLOTTER or GOULD PRINTER, etc) cause switches to be set and a transfer of control to the Graphic Processor Group. Any action which causes the graphic display to be totally redrawn (ZOOM, NEW DRAWING, etc) produces a reprocessing to the display file by the GRAPHIC PROCESSOR GROUP. Changes which produce only additions to the display, require only the expanded file segment to be processed. In order to increase the response time of the system, manipulation of subpictures restricts itself to processing only the subpicture in question and having the old image as graphic litter. At appropriate times, the entire display is redrawn in a "clean-up" cycle.

The exception to the USER GROUP is the "DRAW from the TABLET" subroutine. This routine allows the user to build up a subpicture using geometric forms (lines, rectangles, circles, etc.). In this case, the GRAPHIC PROCESSOR is not used at all, in order to maintain virtually instantaneously response. The subpicture is held in core and allows User to delete any point. This routine issues all draw commands directly to the CRT. When the subpicture is complete, it is merged with the main display file.

In order to fully understand the extent of the program flexibility, note fifteen different capabilities enumerated below.

Graphic Operations of COMPROSPACE

1. Information please - supplies the user with information to instruct him in operation.
2. Grid - allows the user to superimpose a drawing grid of dots or lines on the graphic CRT. The two axis grid may be orthogonal or skew and the spacing along each axis is defined by the user.
3. Fetch Drawing - transfer the named file from tape to the disk scratch area and pass control to the Graphic Processor.
4. Create a New Drawing - initialize a new disk file.
5. Zoom - controls the "viewing window" which the CRT represents. The position and size of this window is controlled by the user referring to actual architectural or engraving scales.
6. Calculate - performs general calculational chores for the user. The distance between two indicated points can be calculated in its representative dimension at the scale at which it is drawn. The areas enclosed by a closed set of straight lines can similarly be requested.
7. Draw from the Tablet - allow the user to build up a subpicture from geometric forms (lines, rectangles, circles, etc.) (the graphic elements). The user indicates the location of necessary verticies (points), such as the center and a point on the circumference of a circle.
8. Manipulate a Subpicture - All graphic entities defined as subpictures can be identified, deleted, translated, rotated or repeated.
9. Add a SGE - A SGE is a named subpicture which can be accessed by the user and added to the drawing. The scale, rotation (about its origin) and location is specified for each use of a SGE. Multiple placement of a given SGE at one scale and rotation is possible by indicating all the locations during one tablet session. Typical SGE's are: pieces of furniture, electrical, mechanical, etc. symbols; a wall, window, structural beam section, or a tone of grey.
10. Store this Drawing - transfer the current file from the disk scratch area to a specified tape unit.
11. Make this drawing a SGE - reprocess the current drawing file and store it on tape as a standard graphic element (SGE). This makes all coordinates relative to the SGE origin and removes any reference to nested subpictures.
12. Hard Copy - commands the Graphic Processor to generate a dot file for the electrostatic dot printer. The printer image is a one to one copy of the CRT display.
13. Plotter Tape -through user interaction, the scale and drawing size are determined. The Graphic Processor then generates the correct plotter command stream.
14. Clean up CRT 2 - Commands the Graphic Processor to erase the display and redraw the current file. This eliminates "litter" and the drawing grid.
15. Erase CRT 2 - allows the user to control CRT 2 so that drawings may be overlaid if desired.

Section 4: Benefits

The designer, the client and the public all benefit in both an economic and a truly personal way whenever the COMPROSPACE program is utilized to work out a new solution to a design problem. In today's world the needs for interaction, speed, economy and accuracy are of top priority.

What could be more important, for example, than how to conserve the available man hours of key professional staff for vitally needed creative work focused on design rather than routine repetititve chores?

Any method that can both shorten and improve the design process in terms of days, weeks and even months will result in a saving of thousands of dollars for the client. Speed and accuracy have been the forte of computer technology and here it is applied to the area of the design process where it can contribute the most. The facility of mathematical and graphic accuracy now allows the designer to undertake an infinitely more complex analysis of a given problem than he was ever allowed to do under the normal restrictions of time and financial budget limitations. Again, this shorter man hour factor shows a saving of up to 60% in the time normally devoted to routine drafting exercises.

An important feature of COMPROSPACE that will result in a considerable saving of time and money is the ability to communicate immediate answers for the client who needs information concerning quantitative data, such as areas and distances, on a given project. Also during a conference, it is frequently necessary to produce a new drawing or to refer to a previously produced drawing which the staff of the client may want to study. Here, COMPROSPACE will provide a quickly printed hard copy document.

Many times important ideas have been lost for future applications because the idea proved not immediately applicable and the designer forgot to keep a record or do a drawing. Here, COMPROSPACE can store drawings and text on the computer tape for the next designer to renew. A broad data base is thus developed inexpensively and effortlessly in a few years.

Consider what a difference it now makes when the client is shown at once the space relationships, alternate room layouts, projected cost data, and a projection of his future needs in one short conference at the architects' office. Now it is possible for the client to contribute to the design with his experience and knowledge by indicating his thoughts while the program is being run and graphic data is created.

Because of the new freedom given the designer when he uses COMPROSPACE, he is allowed time to think creatively. Because of the direct interaction between program and the designer, he can test and evaluate his ideas and store the results for future applications. In fact, each program tape becomes "personalized" to the designer's wish when he creates a file that becomes his own data base.

Section 5: Conclusion

The COMPROSPACE program allows us to draw any subject to scales, use standard graphic elements (SGE) singley or in groups, and manipulate or repeat parts of a drawing independently. This list is by no means complete nor do we have any idea as yet of how many different applications exist for the program. We do know that we will continue to seek new applications for old problems and at the same time, seek to define new problems to which this program can be applied for the improvement of our art and our service.

With the present day trend to simulate via the computer, we have a new technique available with COMPROSPACE - we can create digitized "models" of special building designs. Here the storing of such information for future reference becomes a powerful tool in solving complex design problems. In fact, it will soon become a necessity in the struggle to match the growing magnitude and sophistication of the needs of the changing world. This benefit to the public is long overdue and the role of the designer becomes more vital to the community than ever before realized. It is an opportunity, a challenge and the initiative that must be taken by the designer, now that he has an appropriate tool to do the job with COMPROSPACE and the ARK/TWO system.

Reference

1. Stewart, Clifford D., Eric Teicholz and Kaiman Lee, "Computer/Architecture Programs" reference manual, Center for Environmental Research, Boston, June 1970.

2. Stewart, Clifford D. and Kaiman Lee, "The ARK 2 System: Can a 54-year-old Architectural Firm Find Romance and Happiness With an Interactive Computer System?" Progressive Architecture, July 1971.

3. Lee, Kaiman, "Computer-Aided Professional Services" brochure by Perry, Dean & Stewart Boston, 1971.

23: AUTOMATED SPACE PLANNING

GENERAL SPACE PLANNER: A SYSTEM OF COMPUTER-AIDED ARCHITECTURAL DESIGN: USER DOCUMENTATION

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Introduction

General Space Planner (GSP) is a combination interactive and automated architectural problem solver and drafting system developed at Carnegie-Mellon University (1,2). It is a prototype system implemented to allow exploration of man-machine interaction in the area of architectural design and also exploration of automated design as it pertains to some simple drafting tasks.

GSP was organized to allow a designer sitting at a computer console to design in a way similar to his traditional methods. That is, he is able to build up, alter, evaluate, and change the shape and arrangement of elements quickly and easily. Besides interactive design, GSP includes an efficient automated design program that, given a set of relations that an arrangement is to satisfy, will "design" an arrangement that satisfies them. The user may change the relations of the solution and continue interactively or ask the system to re-solve the revised problem. By further developing this sort of flexibility, we hope eventually to provide architects with a tool that will aid them in their own thinking and problem solving and, when faced with routine issues, may contribute to the design solution on its own.

The purpose of this report is to provide necessary documentation for working with GSP and for adapting it to particular uses. It includes a description of the man-machine interface, the commands available to the user and their function and behavior. Last, this report describes some of the organizational problems encountered in the design of GSP and GSP-like systems. Presented are several ways we have found for managing design procedures that may be of value to others. Several other documents present technical details of the GSP system (3). Readers interested in the internal representation of shapes, the design strategies GSP uses to solve problems, or other issues, are encouraged to refer to these other reports (4).

GSP has been implemented thus far on two time-shared machines, an IBM 360/67 and a PDP-10. The only limitations are that the system be time-shared and allow about 50 K words of core storage during execution. The system is implemented in Fortran IV. It has been running for approximately six months and has been used by both students and a limited number of professionals. And while it was not designed as a production system, it is now being considered for several applications, including the layout of office equipment, reflected ceiling plans, and the layout of electrical power stations. Many alternative modes of problem solving are easily accomodated. Figures One and Two present excerpt examples of two alternative forms of its use. The first depicts an application involving industrialized housing. The user had previously developed a set of interior wall components which he thought would allow a wide variety of useful first floor plans within a given shell. He wished to explore these and refine them. The second example (Figure Two) deals with the automatic layout of mechanical equipment in a highrise building. Here, the equipment has been specified beforehand and the designer gives to GSP the task of solving the arrangement problem. A partial enumeration of the steps GSP took in developing a feasible arrangement is shown in Figure Three.

System Organization

GSP was organized so as to allow a variety of console interfaces including teletypes, plotters, and storage tube graphic terminals. Input is made via a keyboard and output can be received either in approximated form on a teletype or accurately on a plotter or scope.

The current language and command interface has been developed around two design considerations. that seem important for systems that may be used by both experts and novices. First, the system is structured hierarchically. This provides a strong conceptual organization with a structured set of capabilities at each level in the hierarchy. Second, the system optionally provides extensive prompting and verification features for all input. The prompting identifies the commands available, their parameters and arguments each time input is required. The verification gives back to the user the input as interpreted by the computer. These prompting and verification procedures allow use even by novices and the hierarchical structure facilitates learning of the system.

Throughout this report, the following vocabulary is used. We define a command as the description of an action to be taken by the computer immediately, or in certain cases, to be held for

```
-[illegible]

START [illegible]

-DEFINE SHAPES(S):DEFINE RELATIONS(R):INTERACTIVE(I):AUTO.DESIGN(A)
*S

SHAPE DEFINITION MODE

FOLLOWING ARE THE AVAILABLE SHAPE COMMANDS
INPUT    -INDEX(0-15)
OUTPUT   -INDEX,[illegible]
REVISION -INDEX,TYPE OF REVISION([illegible])
NEXT COMMAND *0


DESCRIBE EMPTY SPACE NO. 0
-TYPE(FIUIS),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *E [illegible]
RECTANGLE NO.  2 *E 0 50 12 13
RECTANGLE NO.  3 *E 0 42 13 25
RECTANGLE NO.  4 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 *
NEXT COMMAND *1

DESCRIBE OCCUPIED SPACE NO.  1
-TYPE(FIUIS),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 50 0 1
RECTANGLE NO.  2 *S 0 17 12 13
RECTANGLE NO.  3 *S 20 35 12 13
RECTANGLE NO.  4 *S 21 50 12 13
RECTANGLE NO.  5 *S 0 42 24 25
RECTANGLE NO.  6 *S 2 9 7 8
RECTANGLE NO.  7 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 *
NEXT COMMAND *2

DESCRIBE OCCUPIED SPACE NO.  2
-TYPE(FIUIS),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 1 0 1
RECTANGLE NO.  2 *S 0 1 4 11
RECTANGLE NO.  3 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 *
NEXT COMMAND *3

DESCRIBE OCCUPIED SPACE NO.  3
-TYPE(FIUIS),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 2 0 7
RECTANGLE NO.  2 *S 5 7 0 7
RECTANGLE NO.  3 *S 2 5 5 7
RECTANGLE NO.  4 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 *
NEXT COMMAND *4

DESCRIBE OCCUPIED SPACE NO.  4
-TYPE(FIUIS),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 2 0 8
RECTANGLE NO.  2 *S 2 8 1 2
RECTANGLE NO.  3 *S 3 8 3 4
RECTANGLE NO.  4 *S 2 8 5 8
RECTANGLE NO.  5 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 *
NEXT COMMAND *5

DESCRIBE OCCUPIED SPACE NO.  5
-TYPE(FIUIS),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 1 0 7
RECTANGLE NO.  2 *S 6 7 0 7
RECTANGLE NO.  3 *S 4 6 6 7
RECTANGLE NO.  4 *S 1 2 0 2
RECTANGLE NO.  5 *S 4 6 0 3
RECTANGLE NO.  6 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 *
NEXT COMMAND *6

DESCRIBE OCCUPIED SPACE NO.  6
-TYPE(FIUIS),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 5 0 7
RECTANGLE NO.  2 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 *
NEXT COMMAND *
```

```
-DEFINE SHAPES(S):DEFINE RELATIONS(R):INTERACTIVE(I):AUTO.DESIGN(A)
*I

INTERACTIVE DESIGN MODE

FOLLOWING ARE THE INTERACTIVE OPERATIONS FOLLOWED BY
THEIR ARGUMENTS

   MANIPULATION OPERATIONS -
     REMOVE -(REM),INDEX
     LOCATE -(LOC),INDEX1,INDEX2,X,Y
     ROTATE -(ROT),INDEX,NO. OF [illegible] ROTATIONS
   SEARCH OPERATIONS-
     SCAN-(SCAN),INDEX1,INDEX2
     BOUNDARY-(BOUND),INDEX1,INDEX2,SIDE OF INDEX2
     PERIMETER-(PERI),INDEX1,INDEX2,SIDE OF INDEX2,INDEX
  TEST OPERATIONS-
     VERIFICATION -(V),INDEX,DEVICE
     ADJACENT -(ADJ),INDEX1,INDEX2,SIDE OF INDEX2
     SIGHT -(SIT),INDEX1,INDEX2,PT. ON INDEX1,PT. ON INDEX2
     DISTANCE-(DIST),INDEX1,INDEX2,DISTANCE,PT. ON INDEX1,PT. ON INDEX2
     ORIENTATION -(ORT),INDEX1,INDEX2,SIDE OF INDEX2

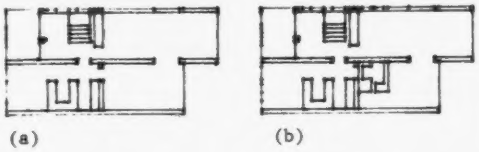
IF SYSTEM IS TO IDENTIFY FAILING RELATIONS WHENEVER THEY OCCUR
-(AUTOTEST). TO TURN OFF -(NOTEST)
FOR TRACE COMMENTS OF EACH OPERATION -(TRACE). TO TURN OFF  -(NOTRACE)

NEXT OPERATION *LOC 0 1 0 0
NEXT OPERATION *ROT 4 2
NEXT OPERATION *LOC 0 4 15 1
NEXT OPERATION *LOC 0 2 28 13
NEXT OPERATION *LOC 0 3 10 17
NEXT OPERATION *LOC 0 6 20 17
NEXT OPERATION *V 0 P
                                        (plan a)
NEXT OPERATION *ROT 5 2
NEXT OPERATION *LOC 0 5 23 13
NEXT OPERATION *V 0 P
                                        (plan b)
NEXT OPERATION *REM 5
NEXT OPERATION *LOC 0 5 23 17
NEXT OPERATION *V 0 P
                                        (plan c)
NEXT OPERATION *REM 5
NEXT OPERATION *ROT 5 2
NEXT OPERATION *LOC 0 5 23 1
NEXT OPERATION *V 0 P
                                        (plan d)
NEXT OPERATION *REM 4
NEXT OPERATION *ROT 4 1
NEXT OPERATION *LOC 0 4 15 1
NEXT OPERATION *V 0 P
                                        (plan e)
NEXT OPERATION *REM 6
NEXT OPERATION *REM 3
NEXT OPERATION *ROT 3 1
NEXT OPERATION *LOC 0 3 23 16
NEXT OPERATION *V 0 P
                                        (plan f)
NEXT OPERATION *REM 3
NEXT OPERATION *ROT 3 2
NEXT OPERATION *LOC 0 6 23 17
NEXT OPERATION *LOC 0 3 29 17
NEXT OPERATION *V 0 P
                                        (plan g)
NEXT OPERATION *REM 5
NEXT OPERATION *REM 4
NEXT OPERATION *LOC 0 5 15 1
NEXT OPERATION *ROT 4 3
NEXT OPERATION *LOC 0 4 29 1
NEXT OPERATION *V 0 P

NEXT OPERATION *

-DEFINE SHAPES(S):DEFINE RELATIONS(R):INTERACTIVE(I):AUTO.DESIGN(A)
*

 TERMINATED: STOP
```



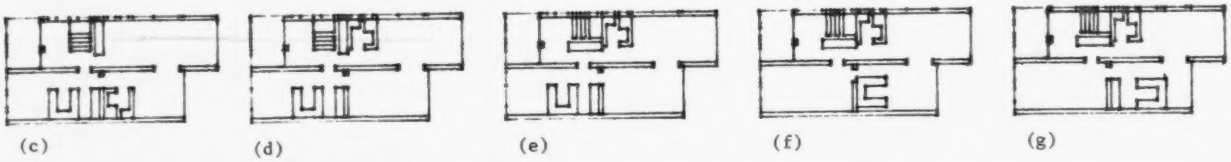
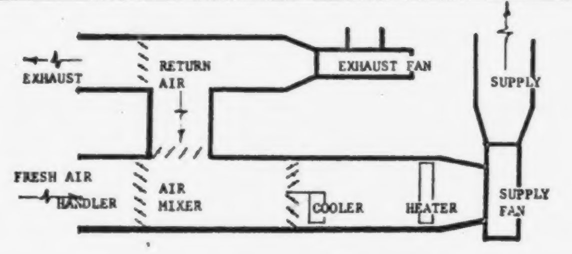


Figure 1. Teletype input and plotter output of work with an industrialized housing unit. The first inputs are descriptions of the modules. They are manipulated and plotted at the right. The "V" operation generates the corresponding plotter drawings.



TYPICAL AIR-CONDITIONING SYSTEM DESIGN

```
GSP
START GSP RUN

-DEFINE SHAPES(S)!DEFINE RELATIONS(R)!INTERACTIVE(I)!AUTO.DESIGN(A)
*S


SHAPE DEFINITION MODE

FOLLOWING ARE THE IMPLEMENTED SHAPE COMMANDS
INPUT    -INDEX(0-10)
OUTPUT   -INDEX,DEVICE(T!P!S)
REVISION -INDEX,TYPE OF REVISION(RA!RP)
NEXT COMMAND *0


DESCRIBE EMPTY SPACE NO. 0
-TYPE(E!U!S),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *E 0 36 1 25
RECTANGLE NO.  2 *E 3 9 0 1
RECTANGLE NO.  3 *E 36 37 10 16
RECTANGLE NO.  4 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 * 11 25
PT.NO.  2 * 6 0
PT.NO.  3 * 26 1
PT.NO.  4 * 37 13
PT.NO.  5 *
NEXT COMMAND *1


DESCRIBE OCCUPIED SPACE NO.  1
-TYPE(E!U!S),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 4 0 10
RECTANGLE NO.  2 *U 0 4 10 20
RECTANGLE NO.  3 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 * 4 5
PT.NO.  2 * 0 5
PT.NO.  3 *
NEXT COMMAND *2


DESCRIBE OCCUPIED SPACE NO.  2
-TYPE(E!U!S),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 8 0 2
RECTANGLE NO.  2 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 * 2 4
PT.NO.  2 *
NEXT COMMAND *3


DESCRIBE OCCUPIED SPACE NO.  3
-TYPE(E!U!S),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 2 0 2
RECTANGLE NO.  2 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 *
NEXT COMMAND *4


DESCRIBE OCCUPIED SPACE NO.  4
-TYPE(E!U!S),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *U 0 4 0 6
RECTANGLE NO.  2 *S 0 4 6 12
RECTANGLE NO.  3 *S 4 6 5 11
RECTANGLE NO.  4 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 * 0 2
PT.NO.  2 *
NEXT COMMAND *5


DESCRIBE OCCUPIED SPACE NO.  5
-TYPE(E!U!S),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *U 0 8 0 4
RECTANGLE NO.  2 *S 0 8 4 16
RECTANGLE NO.  3 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 * 8 9
PT.NO.  2 * 0 9
PT.NO.  3 * 4 16
PT.NO.  4 *
NEXT COMMAND *6
```

```
DESCRIBE OCCUPIED SPACE NO.  6
-TYPE(E!U!S),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 12 0 10
RECTANGLE NO.  2 *U 0 12 10 14
RECTANGLE NO.  3 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 * 12 5
PT.NO.  2 *  0 5
NEXT COMMAND *7


DESCRIBE OCCUPIED SPACE NO.  7
-TYPE(E!U!S),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 8 0 10
RECTANGLE NO.  2 *U 0 8 10 14
RECTANGLE NO.  3 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 * 0 4
PT.NO.  2 *8 5
PT.NO.  3 *
NEXT COMMAND *8


DESCRIBE OCCUPIED SPACE NO.  8
-TYPE(E!U!S),DISTANCE ALONG AXIS OF LEFT,RIGHT,BOTTOM,TOP SIDES
RECTANGLE NO.  1 *S 0 8 0   2
RECTANGLE NO.  2 *
POINT DEFINITION.  X AND Y FROM ORIGIN.
PT.NO.  1 * 8 1
PT.NO.  2 * 0 4
PT.NO.  3 *
NEXT COMMAND *


-DEFINE SHAPES(S)!DEFINE RELATIONS(R)!INTERACTIVE(I)!AUTO.DESIGN(A)
*R


RELATION DEFINITION MODE

FOLLOWING ARE THE IMPLEMENTED RELATIONS FOLLOWED BY THEIR ARGUMENTS!

ADJACENT-(ADJ),INDEX1,INDEX2,SIDE OF INDEX2
SIGHT-(SIT),INDEX1,INDEX2,PT.INDEX1,PT.INDEX2
DISTANCE-(DIST),INDEX1,INDEX2,DIST,PT.INDEX1,PT.INDEX2
ORIENTATION-(ORT),INDEX1,INDEX2,SIDE OF INDEX 2
FOR LISTING OF RELATIONS-(LIST)
FOR CHANGING A RELATION-(REVISE),RELATION NO.

RELATION NO.  1 * ADJ 2 3 1

RELATION NO.  2 * DIST 0 2 2 1 2

RELATION NO.  3 * ADJ 3 4 2

RELATION NO.  4 * DIST 4 5 1 1 2

RELATION NO.  5 * DIST 5 6 1 1 2

RELATION NO.  6 * DIST 6 1 1 1 2

RELATION NO.  7 * DIST 1 0 1 1 4

RELATION NO.  8 * ADJ 6 7 4

RELATION NO.  9 * ADJ 1 6 2

RELATION NO. 10 * DIST 7 8 1 2 2

RELATION NO. 11 * DIST 8 0 3 2 13

RELATION NO. 12 * SIT 6 0 3 1

RELATION NO. 13 *

-DEFINE SHAPES(S)!DEFINE RELATIONS(R)!INTERACTIVE(I)!AUTO.DESIGN(A)
*A


AUTOMATED DESIGN MODE
FORM OF OUTPUT DESIRED -(T!P!S)
*P


DO YOU WISH TRACE STATEMENTS LISTED -(YES!NO)
*NO
```

Figure 2. A problem given to the automated design system. It describes an air handling system for a high rise office building. The sequential generation of results are shown in Figure Three.

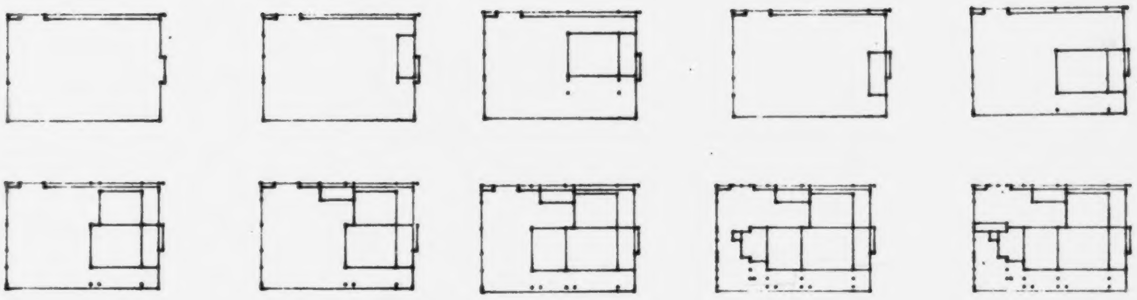


Figure 3. The sequence of drawings generated by the Automated Design Mode while solving the problem defined in Figure Three.

implementation at a later time (see Relation Definition Mode). Within each of the four modes of the system a different set of commands is available. In general, a command is composed of a sequence of parameters, specifying the form of the action to be taken. The parameters are entered in free format in the order specified, separated by commas or blank spaces. No comma follows the last parameter. A parameter can be considered as a variable and as such can receive only a limited set of values. Thus for each parameter, we specify its legal inputs in the form of its arguments.

As shown in Figure Two, GSP presents prompting statements defining the commands, the parameters which comprise a command and the legal arguments for each parameter. These are presented in the following format:

command - parameter (arg.), parameter (arg.),..
where alternative arguments are separated by a colon, within parentheses, and a continuous range defined by a lower and upper bound. The commands available in each mode, their parameters and arguments are enumerated in Appendix One of this report.

The general organization of GSP is shown in Figure Four. The System Level provides an easy interface for accessing the many kinds of actions a user may wish to make. Classes of actions are organized into modes. The actions available within each mode are also depicted. In the following section of this report, each of the modes is described in detail.

The System Level

Upon calling GSP, the user enters the System Level which allows access to each of the four modes. Access of each of the modes is made by specifying one or more parameters. The first parameter defines the mode, and if given by itself, indicates that all prompting and verification statements are desired. On the other hand, if a one (1) is given as an argument for the second parameter, it indicates to the system that the user does not wish commands and arguments to be listed. Similarly, if the user enters a one (1) as an argument to the third

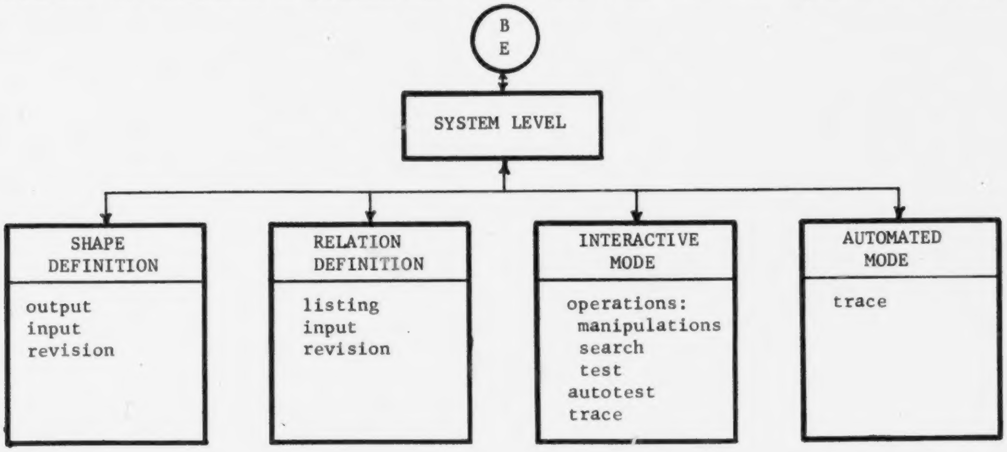


Figure 4

parameter, this indicates that the user does not wish his input to be verified.

Upon receiving a command while in the System Level, GSP calls up the appropriate mode. If an empty line is returned while it is in the System Level, the program terminates. In general, returning an empty line while at any point in the system will exit the user to the next higher task in the hierarchy (where "higher" is in terms of the organization shown in Figure Four).

Shape Definition Mode

The design of a building involves the arrangement of the building on the site, the rooms within a building, and equipment within rooms, plus many other arrangement problems. At one stage, then, the building shell may be a receiving space, in which rooms are to be arranged, and at another time those same rooms may be receiving spaces in which equipment and activity spaces are being arranged. In this way, spaces are treated in several ways during problem solving and any description based on a fixed treatment would be limiting. For instance, spatial elements which are defined in terms of receiving spaces and locatable objects would not allow the flexibility required. Instead, we choose to consider all spatial elements abstractly and call them Design Units (DUs). A DU may be a wall panel, a piece of furniture, the empty space bounded by walls, an activity area, a building, or building site, or any other type of space.*

Currently, GSP treats arrangement tasks in two dimensions only. It represents all DUs in terms of their shape and important point locations on or within the shape. The description of shapes is limited to forms made up of one or more rectangles. As many rectangles may be used to describe a shape as is required. The shapes are of three types:

> Empty Space - which represents areas which are available for receiving other types of space. An example of an empty space would be a room.
>
> Solids - which represent areas of space occupied permanently or semi-permanently. Typically, solids are walls, furniture, machinery;
>
> Use Spaces - which denote spaces occupied temporarily by humans or mechanical equipment. Examples of Use Space are door swings, circulation, or the space used by a person when using a piece of furniture or equipment.

By discriminating between Solids and Use Spaces, GSP allows users to roughly approximate the scheduling of uses to space over time. Because Solids occupy space permanently, they may not overlap with each other or with Use Spaces. On the other hand, Use Spaces occupy spaces only temporarily. Thus several can occupy a space over time. Accordingly, GSP allows overlaps of Use Spaces to occur.

Points are also represented on DUs to facilitate the defining of Relations. The location of plumbing or electrical outlets, a point denoting the viewpoint of a user, are examples where this auxiliary information is used. Up to five points can be specified per DU and each is given a reference number. Sides of a DU can also be referred to by the user of GSP. The sides are given a number from zero to three at the time they are input to the system. At any time thereafter, the user may refer to one of the four sides by giving the appropriate number. See Figure Five.

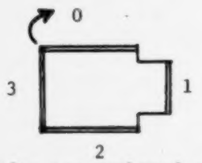


Figure 5. Sides are numbered consecutively from 0 to 3. only those sides on the convex shell of the shape are defined, eg., those marked with a double line.

Relation Definition Mode

The Relation Definition Mode allows input of a set of predefined tests which may be used later to evaluate a partial or complete design. Each test can be considered a constraint which delimits those arrangements which are feasible from those that are infeasible. The tests are treated as a conjunctive set; that is, an arrangement must pass all the tests if it is feasible. When it is executed each test returns a variable which has a value of zero if the test passes or non-zero indicating failure. The result of a test is also listed at the teletype.

The Relation Definition Mode provides commands for entering Relations to the test set and for editing and revising them. A pointer keeps track of the number of Relations currently defined. More can be added or the existing ones altered at any time. Currently four classes of Relations are allowed. (The specific form of parameters for each Relation is given in Appendix One).

> ADJACENT (DU,DU,SIDE) - This test requires two DUs to have partially common borders. It

---

*This generality has not been fully realized in the current implementation. Empty Spaces are now notationally distinct from Occupied Spaces. This distinction will disappear in later versions of the system.

specifically requires that all of the specified side of the second DU in the parameter list have a common border with the first DU. The test is assymmetrical in that all of one side of the first DU may have a common border with the second DU, but a side of the second may not have a completely common border with the first. Thus a Relation of the form ADJ, 11,12,1, would find the first arrangement in Figure Six acceptable but would fail the rest.

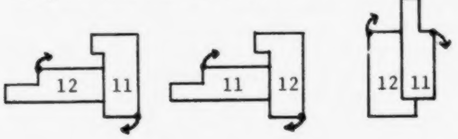


Figure 6. Only the first of these arrangements satisfies the ADJACENT test ADJ,11,12,1. The arrow gives the starting point in numbering the sides.

SIGHT (DU,DU,DISTANCE,POINT,POINT) - This test requires part of the first DU in the parameter list to be in view from a specified part of the second designated DU. The test defines one or two points on each of the DUs and constructs a parallelopiped connecting them. (If two points overlap, the parallelopiped collapses.) The test then checks to see that no DUs other than the two originally specified occupy any point within the parallelopiped. See Figure Seven. In defining a SIGHT relation, the user may either specify a point on the DU which is to be visible or may omit them and let the system identify its own points. The points automatically selected are the diagonal corners which define the complete visual face of the DU with regard to the other DU (See DU11 in Figure Seven). The first point parameter corresponds to the first DU. This test is symmetrical; that is, SIT,1, 2,2,1 is equivalent to SIT,2,1,1,2. One or both point parameters may be omitted.

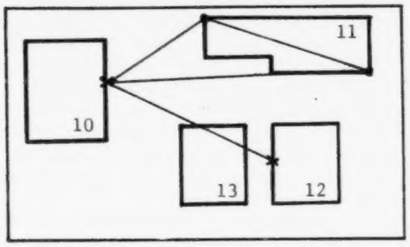


Figure 7. Two SIGHT Relations are shown. The first one between DU 10,Pt.1 and DU 11 passes. The second test between DU 10, Pt.2 fails. NOtice that in the second case the parallelopiped collapses into a line.

DISTANCE (DU,DU,DISTANCE,POINT,POINT) - This test evaluates the straightline distance between two points on two different DUs and passes if this distance is less than the specified value. The points between which the distance is to be measured may either be given by the user (first point belongs to first DU) or if not specified, the point taken is the center of the object as defined by X1 + (X2-X1)/2 and Y1 + (Y2-Y1)/2. (X1 and Y1 are the distance from the origin to left and top sides respectively and X2 and Y2 are the distances of the right and bottom). Again, one or both point parameters may be omitted.

ORIENTATION (DU,DU,SIDE) - This test checks whether the specified side of the second DU is facing or partially facing the first DU. Like ADJACENT, this test is assymetrical.

In the Relation Definition Mode, each of the Relations input are stored for later testing. They can be called forth in both the Interactive and Automated Design Modes, as described below.

Interactive Design Mode
This mode offers to the user three classes of commands each of which takes an immediate action on the DUs. In the following, the three classes of commands are described in detail.

Manipulation Operations: An easy way to understand the manipulation operations in GSP is to view each DU as a template or pattern. To locate a DU, the system overlays its template with the template of the receiving DU and "draws" it in the receiving DU template. The copy of the template now represented in the receiving DU can be considered an image. Rotation of a DU rotates its template (not its image). Removing the image of a DU from the template of another DU involves overlaying the two templates and "lifting the image" from the receiving DU's template. Currently only one image may be generated from each template.

In detail, each of the Manipulation Operators function as follows:

LOCATE (DU,DU,X,Y) - places an image of the second DU in the template of the first DU. It is placed such that the 0,0 location of the cartesian coordinates of the second DU is located in the X,Y point of the first. LOCATE automatically tests that the location specified for the image is legal, that is, does not include any overlaps of Solids with other Solids or Use Spaces and falls completely within empty space. (A legal location may or may not satisfy the relevant Relations). If an illegal location has been proposed, no operation takes place. If the location given is legal, it stores the X,Y location for later retrievals of the DU.

REMOVE (DU) - removes the image of the

specified DU from its current location in the template of some other DU. As only one image is possible, there is no ambiguity which one is to be removed. If the DU has no images, no action is taken.

ROTATE (DU,N) - rotates the template of a DU from its current orientation N times ninety degrees rotated in a positive direction. Thus N = 4 = 0 and N = 5 = 1.

Search Operations: The search operations consist of combinations of Manipulation Operations organized in especially useful ways. Each has the function of locating or relocating a DU according to certain well-defined rules. If the DU is not currently located, it generates a trial location and calls LOCATE. If LOCATE fails another location is automatically generated and LOCATE is called again. The sequence repeats until a legal location is found. If the DU is already located, the operator removes it and a new location is generated. Repeated calls of a Search Operator will generate a series of legal locations. If within a single call of a Search Operator a complete enumeration of locations is made without finding a legal one, such that the search operator regenerates the original trial location of the DU, the operator stops and, like one of the Relation tests, fails. The general rules by which the three search operations work are:

SCAN (DU,DU) - generates an "exhaustive" search of all possible locations in the first DU where the second DU might be located. It moves through the space from left to right, then top to bottom. If SCAN fails with the second DU rotated one way, it calls ROTATE (DU,1) and tries again. All four rotations of the second DU are automatically tried before SCAN fails.

BOUNDARY (DU,DU,SIDE,DU MOVED) - generates sequentially all locations of the second DU inside of the first which allow its specified side to be adjacent with the border of the first DU. This operator moves clockwise along the inside border of the first DU and sequentially tries placements until a legal one is found. All successful placements of the second DU satisfy an ADJACENT test between the appropriate side of the second DU and the receiving DU.

PERIMETER (DU,DU,SIDE) - finds locations of one DU which is adjacent to the second DU. All successful placements satisfy ADJ (DU, DU,SIDE). The last parameter designates which of the DUs are to be moved; it must have the same value as the first or the second DU parameter.

Test Operations: The third class of operators are test operations. They are the same set which can be defined in the Relation Definition Mode. Here, though, the tests are implemented immediately and the results given.

Besides the three classes of operations, the interactive Design Mode also provides the capability for "background" testing of the Relations input in the Relation Definition Mode. This feature is called "Autotest". When Autotest is "on", all Relations which have been specified in the Relation Definition Mode and which involve DUs having images in a single template are used to automatically evaluate the arrangements. The user is notified whenever any specified test fails.

Automated Design Mode

This mode of GSP incorporates an automatic problem solver that has been shown to efficiently solve many arrangement tasks. When this mode is called it attempts to build up from scratch, add to, or adjust an arrangement so that all DUs in it are located in a way that satisfies the set of Relation tests currently specified. The problem solving method is heuristic in nature. That is, it will not always succeed, even if a solution exists. Similarly, it may get into an endless loop or some other problem. Thus its progress should be monitored from time to time.

Before problem solving, this mode asks the user the form of monitoring desired and the type of device on which the monitoring and the final arrangement are to be displayed.

The user can request verification of his shape description or output of any template in one of the three output devices. The plotter and scope provide scaled drawings as verification. The teletype approximates the scaled output by presenting a non-scaled two-dimensional array (generally known as a variable dimensioned array (5)). An example is given in Figure Eight. The variable dimensioned array is two dimensional, with zero vectors. The zero vectors give the cartesian distance to the right hand or bottom side of each row and column. The value of each non-zero array variable denotes what occupies the corresponding domain of space. The following code is used:

1 - Empty Space
10-19 - Use Space
89-99 - Solid Space
400 - Null Space

After the array is output, a listing of points for the template and all images in the template are also listed.

```
REPRESENTATION OF THE ACCEPTING SPACE


           8    9   17   20   35   41   42   50    0
 1       400  100  100  100  100  100  100  100  400
 7       400   10   10   10   10   10   10   10  400
 8       400  100   10   10   10   10   10   10  400
12       400   10   10   10   10   10   10   10  400
13       100  100  100   10  100   10  100  100  400
24        10   10   10   10   10   10   10  400  400
25       100  100  100  100  100  100  100  400  400
 0       400  400  400  400  400  400  400  400  400
```

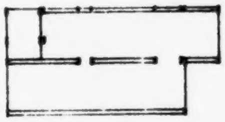


Figure 8. Variable dimensioned array and the corresponding plotter drawing.

Organizational Issues in the Design of Space Planning Systems

The underlying operational structure of GSP is its definition of spatial elements in terms of templates and a set of operators which transform the templates and their images in specified ways. This organization allows partial arrangements to be easily depicted and also the potential for recursive operations on templates within other templates (not yet realized in GSP). Multiple images of templates are another possible flexibility not yet realized. By keeping templates of a shape, it is possible to remove their images even when they overlap. Without a template, what should be taken out would be problemmatical.

The current template organization requires that certain combinations of actions not be allowed. This includes rotating a template after an image of it has been generated. In removing an image, the template is currently laid over the image without any intervening check on rotations. The lack of intervening rotations precludes locating multiple images of the template also, if the different images should be rotated in different ways.

An alternative organization that would eliminate these limitations would be to keep each template in a fixed orientation and only rotate images of it prior to mapping them into a location on another template. Removing an image then requires the generation of a dual image which is rotated to match the original and used to "subtract out" the original. This organization allows multiple images and, incidentally, locating DUs at skewed angles (rotations ≠ 90°).

The Relation tests currently implemented are those needed to represent simple arrangement tasks for automatic resolution. Analytic techniques of a more powerful nature are in order, particularly if the interactive mode is to be emphasized. Circulation analyses, cost estimates, heat and energy load and consumption are types of analyses that could be implemented within the basic structure proposed here, for use interactively.

Production applications are likely to require stored descriptions of DUs so as to eliminate the time consuming task of inputting them from teletype. This can be accomplished using appropriately structured files and a coding scheme.

We expect to introduce these and other improvements to GSP in the near future.

Notes

1. This work is supported by the National Science Foundation, grant no. GJ31188 made to the Institute of Physical Planning, Carnegie-Mellon University.
2. The author has been aided in both the implementation and formulation of GSP by Christ Yessios and Michael Schwartz.
3. See: Eastman, C. (1972) "A Preliminary Report on a System for General Space Planning", Communication of the Association for Computing Machinery, (in press); Eastman, C, (1971a) "GSP: A System for Computer Assisted Space Planning", Proceedings Design Automation Workshop, Atlantic City, N.J.; Eastman, C. (1971b) "Heuristic Algorithms for Automated Space Planning", Proceedings of the Second International Joint Conference on Artificial Intelligence, London, England.
4. Perceptive readers will notice that each of the descriptions of GSP vary from one another. This is because it is constantly undergoing changes, as is expected of a prototype and experimental system. In general, the most recent paper takes precedence over earlier ones in describing the current status of GSP.
5. See: Eastman, C.(1970) "Representations for Space Planning", Communications of the Association for Computing Machinery, April, 13:4, pp. 242-250.

APPENDIX ONE

Below are listed the different modes of interaction within GSP. Presented are the commands available and their legal arguments.

COMMAND SYSTEM

General Use: Allows the user to access the different modes of the system. It also provides means for the user to control the form of prompting and input verification he will receive.

Commands:	Parameters and Arguments	Interpretation
ENTER MODE	mode type - (S)	Shape definition
	(R)	Relation definition
	(I)	Interactive Mode
	(A)	Automated Design Mode
	prompting desired - (defaulted)	full prompting
	(1)	no listing of parameters
	verification desired - (defaulted	full verification
	(1)	no verification

SHAPE DEFINITION MODE

General Use: This mode is for entering DUs for later use or to modify the descriptions of those already entered. Output verification of DU descriptions is also offered.

Commands:	Parameters and Arguments	Interpretation
OUTPUT	(V)	Verification of output
	index - (0)	for an Empty Space
	(1- 10)	for an Occupied Space
	device - (T)	for output on teletype
	(P)	for output on plotter
	(S)	for output on scope
REVISION	type of revision - (RP)	for revision of points description on
	(RA)	for revision of complete description
	index - (0)	for an Empty Space
	(1- 10)	for an Occupied Space
INPUT	index - (0)	for an Empty Space
	(1- 10)	for an Occupied Space
(upon receipt of an enter command)		
SHAPE INPUT	rectangle type - (E)	Empty Space; can only go in spaces indexed 1-9
	(U)	Use Space can only go in spaces indexed 10-99
	(S)	Solids
	X1 - (integer)	distance along axis from origin to left side of rectangle
	X2 - (integer)	distance along axis from origin to right side of rectangle
	Y1 - (integer)	distance along axis from origin to top of rectangle
	Y2 - (integer)	distance along axis from origin to bottom of rectangle.
(upon receipt of an empty SHAPE INPUT command)		
POINT INPUT	X - (integer)	distance along axes from origin to point
	Y - (integer)	
	(origin)	input point 0,0

RELATION DEFINITION MODE

General Use: This mode is used for specifying Relations that will later be used to evaluate the system, in either the Interactive or Automated Modes. Each Relation is assigned a number. The Relations that can be specified are:

Commands	Parameters and Arguments	Interpretation
ADJACENT	(ADJ)	
	index 1 - (0-10)	the two DUs to be adjacent
	index 2 - (1-10)	
	side of index 2 - (1-4)	side of second DU to have common boundary with first DU.

RELATION DEFINITION MODE (CONTINUED)

Commands	Parameters and Arguments	Interpretation
SIGHT	(SIT)	
	index 1 - (0-10)	the two DUs between which this sight test is made
	index 2 - (0-10)	
	pt. on index 1 - (1-5 or blank)	points to be in view of one another. If one or more is blank, whole object must be in view.
	pt. on index 2 - (1-5 or blank)	
DISTANCE	(DIST)	
	index 1 - (0-10)	the two DUs between which the distance test is made
	index 2 - (0-10)	
	distance - (integer)	allowed distance between the 2 DUs
	PT1 - (1-5 or blank)	points on DUs from which distance is to be measured. If blank, distance is measured from the centroid of DU.
	PT2 - (1-5 or blank)	
ORIENTATION	(ORT)	
	index 1 - (0-10)	reference DU
	index 2 - (0-10)	DU which is to have proper rotation
	side of index 2 - (1-4)	the side of DU2 which should face DU1
(the following commands are implemented immediately)		
LISTING	(LIST)	lists the Relations input thus far by number assigned and their arguments
REVISION	(REVISE)	
	Relation No. - (1-40)	number assigned to the Relation to be revised

INTERACTIVE DESIGN MODE

General Use: Allows the user to call and implement all operations available in GSP. Each operation is implemented immediately. This mode also allows automated testing of Relations as operations are being made.

Commands:	Parameters and Arguments	Interpretation
LOCATE	(LOC)	
	index 1 - (0)	Receiving DU
	index 2 - (1-10)	DU to be located
	X - (index)	location of 0,0 point
	Y - (index)	of DU2 in coordinate system of DU1
REMOVE	(REMOVE)	
	index - (1-10)	DU to be removed from its current location
	(ROT)	
	index - (0-10)	DU to be rotated
	number - (1-4)	Number of +90° rotations
SCAN	(SCAN)	
	index 1 - (0)	receiving DU
	index 2 - (1-10)	DU to be placed
BOUNDARY	(BOUND)	
	index 1 - (0)	receiving DU
	index 2 - (1-10)	DU to be placed
	side of index 2 - (0-3)	side of DU2 to be adjacent to perimeter of DU1
PERIMETER	(PERI)	
	index 1 - (1-10)	two DUs to be adjacent
	index 2 - (1-10)	
	side of index 2 - (0-3)	side of DU2 to be adjacent to DU1
	index - (same as index 1 or index 2)	DU to be relocated

INTERACTIVE DESIGN MODE (CONTINUED)

Test operations are the same as specified in the Relation Definition Mode. Here, though, the evaluation is made immediately.

Commands	Parameters and Arguments	Interpretation
AUTOMATED TESTING	(AUTOTEST)	system evaluates the current arrangement according to Relations defined in Relation Definition Mode automatically after each operation.
	(NOTEST)	negates AUTOTEST
TRACE LISTING	(TRACE)	listing is given of many intermediate values of variables within operation subroutines
	(NOTRACE)	negates TRACE

AUTOMATED DESIGN MODE

General Use: Generate an arrangement that satisfies all the relationships input in Relation Definition Mode. The method is by a build-up approach.

Commands:	Parameters and Arguments	Interpretation
OUTPUT MODE	device - (T)	for output on teletype
	(P)	for output on plotter
	(S)	for output on scope
TRACE LISTING	(Y)	listing of intermediate values of variables within operation subroutines
	(N or blank)	negates trace

THE ANIMALS OF ARCHITECTURE

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Introduction

The architect is an educator. As such, when faced with a problem such as designing a house he must take a client's inherent values into consideration. If he does not, he reduces himself to a salesman.

The method to be described in this paper has been generated by the need to analyze and operate with these client-centered value judgements. (1) This educative, diagnostic method supports the philosophy of user-generated design. Utilizing computers may not significantly change the design process. However, because of the possibility of efficiency, the architect would be able to deal with more complex housing problems in a design process similar to a client-architect relationship.

The technique that has been created will transform a set of proxemic distances generated by a client into an optimal spatial layout. This will be in terms of the minimum absolute difference in the summation of distances between the pattern and the given set.

Techniques that can assist in the analysis of the problem have been developed and applied during the past 10 years. These include hillclimbing, graph theory, factor analysis, multidimensional scaling and numerical taxonomy. However, the problems that have been encountered in these areas would limit the development of their ability to generate spatial patterns.

In hillclimbing techniques the use of a random number generator reduces the probability of an optimum solution being found. If clustering techniques are used to create classes the solution space has been merely reduced rather than limited to one. For example in the nine-element case, if three classes of three are found, the number of solutions implied will be $\frac{9!}{3!X3!X3!}$ or approximately 1,700.
It is possible that these problems can be overcome. However, many of these techniques have come from other disciplines and may have inherent contextual assumptions built into them.

This paper introduces a different approach to the spatial pattern problem based on the cell growth problem first defined by Harary in 1958 with the major contribution made by Read in 1962.(2) Read created enumeration methods in relation to spatial patterns that he calls "animals". The constraints were that the square cells placed in a square grid had to be contiguous before an animal could be created.

eg. when $n = 3$, the number of animals = 2
when $n = 9$, the number of animals = 1,285
when $n = 20$, the number of animals > $3.4 X 10^9$
(according to Lunnon)

It is obvious the numbers quickly become unmanageable. By orientating the pattern the number of possibilities is equal to the number of patterns multiplied by eight. Also, with each pattern and orientation there are n! ways of labelling the cells. Disregarding obvious design constraints we can establish the solution boundary for the nine-cell case as:

pattern X orientation X arrangement
or 1285 X 8 X 362,880
or approximately 3.4×10^9

The problem is to find one solution by logical deduction.

An important aspect of systems studies is to be able to define the limits of the solution space and to accept axioms that theories can be created on. This is now possible because of the initial work of Read and the many developments within the cell growth problem. Because this area is quite diversified in mathematics it gives numerous opportunities for development.

Lunnon (3) has indicated the magnitude of the 20-element case in private correspondence with the authors of this paper. He has graphically produced all animals for $N \leq 12$. The significance of this lies in our ability now to classify the patterns according to behaviour, image, economics etc.

In addition to Read's enumeration methods, Klarner (4) has developed a mathematical method of packing small sets of patterns into larger structural units considered in three-dimensional space.

"Life game" is another area that has been developed from Read's basic premise. Although "life game" has not been applied to building problems, it is possible to simulate the growth of cities by developing the existing rule systems.

The optimization method presented in this paper is only the first phase in exploring the methods of abstracting and modelling spatial pattern problems that exist in the man-made environment.

The Method

The method will show how a pattern of square cells can be built from a given set of preferences of pairwise distances between all the cells, such that the built pattern will minimize the absolute difference between all the distances of the pattern and all the given distances.

The matrices that are created (i.e., B, A and R), rearrange the given information in such a way that a two dimensional pattern can be created. At the same time a pattern that is the most opposite (i.e., the one that maximizes the differences in distances) to the given distances is also created.

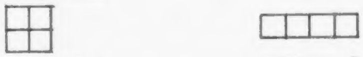
The matrices of both patterns can be compared to the original set of preferences and a value established that represents the degree to which the preference requirements have been satisfied. In many cases, the preferences will not have been satisfied totally; consequently a feedback loop allows the operator to re-evaluate the pattern and conflicts and if necessary redefine the preferences iteratively until a satisfactory pattern is found.

Preference Information

Within the context of the problem it is known that human value judgements will be obtained at varying levels in order to find pattern. This means that an interface between the value judgement and a set of distances has to be established.

The first decision must be to determine the number of cells that will be considered in the system. This in turn will determine the total number of pairwise distances that have to be considered; that is the number of pairwise distances is $\frac{n(n-1)}{2}$, where n is the number of cells.

A pattern determined from the pairwise distances will be biased due to the individual values of the set of distances and the distribution of these values; e.g., in fig 1, if the values and distribution of pattern 1 are given then it will be a square and if pattern 2 it will be a string. The solutions are predetermined; however, the degree to which they are predetermined will be severely reduced in larger systems.



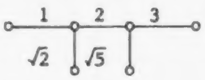
values	distribution
1	4
2	2

values	distribution
1	3
2	2
3	1

fig 1

As the distribution of values has such an effect on the pattern we will allow the distribution of preferences to be made freely. Further it does not seem possible to create the distribution without creating a complete enumeration of patterns.

From the first decision on the number of cells we can determine the specific values that are possible. The two examples shown in fig 1 are extreme; we can determine the total set of distances from fig 2.

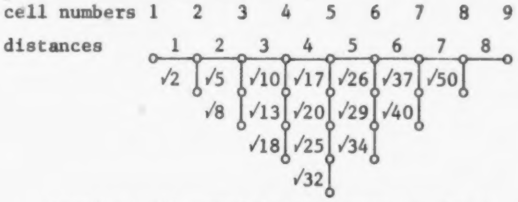


Graph of all possible distances in the 4 element case

fig 2

A similar diagram for the n cell case can be constructed by considering that the maximum distance will be n-1 and that the paths from the origin cannot be greater than (n-1).

Because the major effect of this method will be in the manipulation of large systems, the 9 element case will be illustrated as a more complex example. fig 3 gives the total set of possible distances for n = 9



Graph of all possible distances in the 9 element case

fig 3

In preference tests there is the danger that more precise information is obtained by sampling than actually exists. In the situation of a house, where an individual has the problem of judging the value of the different proxemic distances, it is possible that only a few distinctions can be made, i.e., close, not so close, and distant. In the other extreme, it is possible that the same person, when confronted with two or three specific distances in the house, could decide that one was more positive or more negative than the other and by some process be able to discriminate among all the distances. The situations described can generally be classified as a free choice and a forced choice.

A free choice can be defined as one where the individual can decide the degree to which he can discriminate. One problem with this method is the fact that a great many possible distances exist for a relatively simple problem and therefore the degree of satisfaction on the first itteration could be low.

A forced choice can be defined as one where the individual is forced to make value judgements. The complete set of pairwise distances in the system is forced into a rank order from closest to furthest distance. Stevenson (5), as a small part of his work, has described a method of systematically making these judgements. The method is simply to illustrate all the values that have to be sorted on individual cards and then to consider each value and place it on either of three bundles. Each bundle represents either a positive, negative or no opinion reaction to the value. After completing the sort, each bundle is organized into three more bundles so that nine bundles are obtained. In Stevenson's method a normal distribution of values is required therefore only so many cards can be allowed on each bundle. This method has been used by the author (6) in previous work to analyse the data by factor analysis in producing a classification of the values. In this context, the method must be adapted to produce a rank order which can be accomplished by firstly giving free choice to the number of cards on each bundle. Secondly, the bundles can be ordered and combined to ensure that the highest value of one bundle is less than the lowest value of the next bundle.

A criticism of preference testing has been the human problem of intransitive values. In the methods mentioned this problem has been alleviated because the preferences are made by sequencial comparisons among the pairwise distances.

In the pattern building problem the solution to finding a pattern that fits the criteria will be found by manipulating a matrix that is derived from the preferences. In equation 1 the elements of the matrix correspond to the preferences for the distances between the cells of a pattern, e.g., cell 2 is preferred to be separated from cell 4 by a distance of √2 units. This is the value of element 24 in the matrix B.

$$B = \begin{bmatrix} 0 & 1 & 2 & 1.4 & 2.2 & 3.2 & 4.1 & 5.1 & 6.1 \\ 1 & 0 & 1 & 1 & 2 & 3 & 4 & 5 & 6 \\ 2 & 1 & 0 & 1.4 & 2 & 3.2 & 4.1 & 5.1 & 6.1 \\ 1.4 & 1 & 1.4 & 0 & 1 & 2 & 3 & 4 & 5 \\ 2.2 & 2 & 2 & 1 & 0 & 1 & 2 & 3 & 4 \\ 3.2 & 3 & 3.2 & 2 & 1 & 0 & 1 & 2 & 3 \\ 4.1 & 4 & 4.1 & 3 & 2 & 1 & 0 & 1 & 2 \\ 5.1 & 5 & 5.1 & 4 & 3 & 2 & 1 & 0 & 1 \\ 6.1 & 6 & 6.1 & 5 & 4 & 3 & 2 & 1 & 0 \end{bmatrix} \quad (1)$$

In general the Behavioural matrix B is defined by
1) B is a square symetrical matrix of order n, where n is the number of cells in the pattern.
2) b_{ij} is the preferred distance between the centroid of cell i ¢ cell j.
3) $b_{ii} = 0$

Association Matrix (A)

Between any two cells in a system there is a value of association. This value can be found by comparing two cells to a third, if each of the first two cells relates to the third then there is a value of association between the first two cells caused by the third cell eg. if A→C and B→C then A→B by association of C.

In general the value of association between two cells can be found by comparing the absolute difference in distance to each and every other cell of the system as shown in equation (2).
from (1) ¢ (2) the A matrix (3) can be generated

$$a_{ij} = \sum_{\substack{m=1 \\ j\neq m\neq i}}^{n} |b_{im} - b_{jm}| \quad (2)$$

$$A = \begin{bmatrix} 0 & 2.1 & 0 & 6.3 & 10.1 & 14.3 & 17.3 & 19.9 & 20.9 \\ 2.1 & 0 & 2.1 & 5.8 & 10.4 & 15.4 & 18.2 & 21.2 & 22.2 \\ 0 & 2.1 & 0 & 6.3 & 10.1 & 14.3 & 17.3 & 19.9 & 20.9 \\ 6.3 & 5.8 & 6.3 & 0 & 6.6 & 11.6 & 16.4 & 19.4 & 22.4 \\ 10.1 & 10.4 & 10.1 & 6.6 & 0 & 7.0 & 11.8 & 16.8 & 19.8 \\ 14.3 & 15.4 & 14.3 & 11.6 & 7.0 & 0 & 6.8 & 11.8 & 16.8 \\ 17.3 & 18.2 & 17.3 & 16.4 & 11.8 & 6.8 & 0 & 7.0 & 12.0 \\ 19.9 & 21.2 & 19.9 & 19.4 & 16.8 & 11.8 & 7.0 & 0 & 7.0 \\ 20.9 & 22.2 & 20.9 & 22.4 & 19.8 & 16.8 & 12.0 & 7.0 & 0 \end{bmatrix} \quad (3)$$

The association matrix A is defined by
1) A is a square symetrical matrix of order n, where n is the number of cells in the pattern
2) a_{ij} is found by (2)

3) $a_{ii} = 0$

If the association matrix had similar characteristics to the behavioural matrix then it would be possible to begin to build a pattern from the least valued link. This is not so as can be seen from element 13 in both A & B matrices in equations (1) and (3). The reason for this problem is that symetrical ordering (in its simplest form) is represented by an element in the A matrix as zero.

The idea that has generated the association matrix has come from the use of factor analysis in problem solving. Factor analysis method uses an intercorrelation matrix which is similar to the association matrix. A noticable difference in factor analysis is the use of normalizing rows before taking a measure of their relations. A possible flaw is the lack of emphasis given to a direct score between the rows compared, and a dependance on the value of intercorrelation. Harmon (7) makes a similar observation concerning methods other than his own method, noting that the dependance on intercorrelation will not give proper results.

The Resolution Matrix (R)

In the B matrix a large number of equivalent values exist. This leads to a situation so that there is no indication on where to begin building the pattern. While the A matrix disperses the values its elements may not have the same ordering as those in B due to problems of symetry.

Consequently the matrix that is needed to build the patterns must restore the ordering of the elements in B while maintaining the dispersal of the values of the elements of A. Such a matrix will be called a resolution matrix (R).

The resolution matrix R is defined by
$R = \propto B + A$ --- (4)
wherein $\propto$ is a number which will increase the relative values of the elements of B to such a degree that they will overcome the symetrical ordering in A.

Alpha

If the ordering of A is the same as the ordering of B then there can only be one solution to the pattern. The pattern must be a straight snake or tromino. If there is at least one reversal in order (ie. if an element of A has a value in B that makes any list of the matrices dissimilar) then the solution must contain an angle snake or tromino in (5) and (6)

straight

$$\begin{array}{|c|c|c|}\hline 1 & 2 & 3 \\ \hline \end{array}\ , \ B = \begin{bmatrix} 0 & 1 & 2 \\ 1 & 0 & 1 \\ 2 & 1 & 0 \end{bmatrix} \ , \ A = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix} \ , \quad (5)$$

angle

$$\begin{array}{|c|c|}\hline 1 & 2 \\ \hline \multicolumn{1}{c|}{} & 3 \\ \cline{2-2} \end{array}\ , \ B = \begin{bmatrix} 0 & 1 & 2 \\ 1 & 0 & 1 \\ 2 & 1 & 0 \end{bmatrix} \ , \ A = \begin{bmatrix} 0 & (\ 2-1) & 0 \\ (\ 2-1) & 0 & (\ 2-1) \\ 0 & (\ 2-1) & 0 \end{bmatrix} , \quad (6)$$

In (6) the R matrix must restore $r_{13} > r_{12}$
In the example then

$r_{13} = \alpha b_{13} + a_{13}$

and $r_{12} = \alpha b_{12} + a_{12}$

but $r_{13} > r_{12}$

then $\alpha b_{13} + a_{13} > \alpha b_{12} + a_{12}$

or $\alpha\sqrt{2} + 0 > \alpha + (\sqrt{2}-1)$.

$0.4\alpha > 0.4$
$\alpha > 1$
or $= 2$ (7)

therefore

$$R = \begin{bmatrix} 0 & , 2.4, & 2.8 \\ 2.4 & , 0 & , 2.4 \\ 2.8, & 2.4, & 0 \end{bmatrix} \qquad (8)$$

In general the following method can be used to find all α values from any B & A matrix.

$$\alpha > \frac{a_{kl} - a_{ij}}{b_{ij} - b_{kl}} \qquad (9)$$

where a_{ij} is any element in A that is out of order in B.
b_{ij} is the corresponding element in B.
b_{kl} is any element value in B that is less than the value of b_{ij}
a_{kl} is the corresponding element in A.

In (1) and (3) the maximum value of alpha can be calculated to be 25.
The R matrix is then (10)

$$(10)\ R = \begin{bmatrix} 0 & 27.1 & 50.0 & 41.3 & 65.1 & 94.3 & 119.8 & 147.4 & 173.4 \\ 27.1 & 0 & 27.1 & 30.8 & 60.4 & 90.4 & 118.2 & 146.2 & 172.2 \\ 50.0 & 30.8 & 0 & 41.3 & 65.1 & 94.3 & 119.8 & 147.4 & 173.4 \\ 41.3 & 30.8 & 41.3 & 0 & 31.6 & 61.6 & 91.4 & 119.4 & 147.4 \\ 65.1 & 60.4 & 65.1 & 31.6 & 0 & 32.0 & 61.8 & 91.8 & 119.8 \\ 94.3 & 90.4 & 94.3 & 61.6 & 32.0 & 0 & 31.8 & 61.8 & 91.8 \\ 119.8 & 118.2 & 119.8 & 91.4 & 61.8 & 31.8 & 0 & 32.0 & 62.0 \\ 147.4 & 146.2 & 147.4 & 119.4 & 91.8 & 61.8 & 32.0 & 0 & 32.0 \\ 173.4 & 172.2 & 173.4 & 147.4 & 119.8 & 91.8 & 62.0 & 32.0 & 0 \end{bmatrix}$$

The resolution matrix R is defined by
1) R is a square symetrical matrix of order n, where n is the number of cells in the pattern
2) $r_{ij} = \alpha b_{ij} + a_{ij}$
3) $r_{ii} = 0$

The requirements of R have been satisfied and the elements of R can be listed with the most connected link having the minimum value and the most disjointing having the maximum value.

Pattern Building

In patterns the corresponding form to a link or edge is the domino, ie a two cell pattern. If we had to proceed using the domino it would be very difficult to develop patterns as the domino is of one form, however, the tromino has two forms (already illustrated in (5) & (6)) which allows the choice to build in straight or angled pattern. To go to larger polyominos has little meaning as the tromino gives the option to change in direction in the two axes of the pattern, which is the only option needed.

The corresponding data structure to the tromino is the triad, which could also be referred to as a simplex. The triad has three edges and satisfies the same criteria as the link ie. that a sumation of the values of the edges determines the importance of the triad. If it has the minimum value of all triads then it will be placed first to satisfy the problem of minimizing the absolute differences of distances. If on the otherhand the triad had the maximum summation of distances then it would be placed first to maximize the difference between the absolute distances.

In either case the process of building the pattern will be to place the most dominant (either maximum or minimum) triad as a tromino. The purpose of the triad has been to determine which three cells in the system interact either most positively or most negatively with the other cells, no more information than this can be deduced from the R matrix. The coordinates of the links of the triad in the B matrix will give more information on the exact nature of the tromino. Fig 4 shows the relation between the list of links, their values, the triads created in a partial listing of the R matrix and the values of the elements in B that correspond to the elements in the triads. In cases where the information does not precisely fit the tromino then the comparison to the elements of B in the triad and the individual values must be used to decide on the correct tromino. If a decision is not clear then all trominos should be placed and a comparison made between the submatrix of B & B_s. The B_s matrix has the same definition as the B matrix except that the values B_{sij} are the actual distances from the generated pattern.

link	value	triad	b_{ij}	b_{ik}	b_{jk}	$\Sigma b_{i,j,k}$
14	41.29	124	1	1.4	1	3.4
34	41.29	234	1	1	1.4	3.4
13	50.00	123	1	2	1	4.0
25	60.39	245	1	2	1	4.0
46	61.59	456	1	2	1	4.0
57	61.79	567	1	2	1	4.0
68	61.79	678	1	2	1	4.0
79	62.00	789	1	2	1	4.0
15	65.09	125	1	2.2	1	4.4
35	65.09	345	1.4	2	1	4.4

Partial listing of the R matrix
fig 4
(with triads and related elements of B)

Maximize - Minimize

In designing a method of pattern building, the measurement of such a method must be in the degree to which the given requirements have been satisfied in the pattern. In order to standardize the measurement over different distributions in the B matrix and in the size of the system we will produce a ratio measure.

The numerator of the ratio measure will be made between the B matrix and the B_s (min) matrix, which is the B_s matrix generated from the minimum difference pattern. The denominator being the difference between the B mátrix and B_s (max) matrix which is created from the maximum difference pattern such that the degree of satisfaction

$$S = 1 - \frac{B \theta B_s \text{ (min)}}{B \theta B_s \text{ (max)}} \quad (11)$$

where the operation θ on two square matrices M and N is defined by

$M \theta N = c$

such that $c = \sum_{i,j=1}^{n} |m_{ij} - n_{ij}|$

Optimum Solution

The optimum solution, subject to the constraints implied by the following rules, can be found by the procedure outlined hereinafter.

Rule 1 Triads and their associated trominoes must be considered sequentially in ascending or descending order.

Rule 2 A given tromino can only be added to and combined with the pattern if two of its three cells already exist in the pattern. These two cells must be in the same relation to each other in both the tromino and the pattern; otherwise the tromino cannot be considered.

Rule 3 The pattern must be contiguous at all stages.

Rule 4 If a given tromino can be added to the pattern in two ways, and if no immediate distinction can be made between the two ways, then both solutions must be considered in further building.

Procedure

Step 1 Select the most important triads. In fig 4 the most important minimum triad is 124 and equally 234. From the same problem we can find the most important maximum triad to be 139.

Step 2 Place the triads into the trominoes that have the closest link values to the link values of the triad. To place the triad in the maximum pattern place the link values in the most oposite configuration. eg from fig 4 the triads 124 and 234 would be placed in trominoes T_1 and T_2 as in (12)

$$T_1 = \begin{array}{|c|c|}\hline 1 & 2 \\ \hline \multicolumn{1}{c|}{} & 4 \\ \cline{2-2}\end{array} \quad \text{and } T_2 = \begin{array}{|c|c|}\hline 3 & 2 \\ \hline \multicolumn{1}{c|}{} & 4 \\ \cline{2-2}\end{array} \quad - (12)$$

Step 3 After placing the triads into trominoes, the trominoes must be placed together into pattern P under the constraint of rule #2. If this rule cannot be satisfied then the triad, next in importance should be placed (ie repeat steps 1 and 2) and combined if possible with T_1 to creat a pattern P. In the eg T_1 and T_2 can be combined to form P_4 (the subscript referring to the number of cells combined in the pattern.) The only solution to P_4 would be (13)

$$P_4 = \begin{array}{|c|c|c|}\hline 1 & 2 & 3 \\ \hline \multicolumn{1}{c|}{} & 4 & \multicolumn{1}{c}{} \\ \cline{2-2}\end{array} \quad -- (13)$$

Step 4 If in the process of orienting a pattern there are two indistinguishable alternatives, then both must be accepted and an evaluation carried out at this stage. The evaluation must be between each of the submatrices of the spacial patterns and the behavioural matrix. In each case the sum of the difference between the element values can be used to determine the better pattern. This will be defined by the lesser of the sums.

Step 5 If, in the process of selecting the triads, a triad is encountered that has less than two cells in common with a triad previously considered then a parallel building process will be started until the sub-pattern has two contiguous cells in common with another sub-pattern.

When the complete pattern is generated, the degree of satisfaction can be calculated from (11).

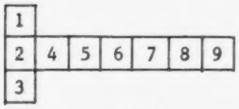


fig 5
The optimal pattern

Since the preference information in this example was taken directly from the pattern that is found to be optimum(fig 5)it is obvious that the satisfaction index is 1. A part of the verification of this method has been that the set of distances from the pattern would recreate the pattern.

The foregoing example has produced a pattern from a given set of distances that were generated from the pattern. It is however, necessary to consider the implications of the method where the given information is of an imprecise nature. This is the projected use of the method.

The process of considering the triads is the most fundamental idea of the paper. The meaning of the process is that any triad that is considered below another is of lesser importance and consequently to combine the triads out of sequence will lead to sub-optimization. Since by definition the pattern is contiguous it is necessary to force a triad into a contiguous tromino if all other procedures have failed to build the complete pattern.

The method could easily be adapted to consider disjoint patterns. As the triads are sequential it is always known that the next triad to be joined will create a contiguous pattern. This rule could be ammended to allow each new cell to take its optimal position in relation to the existing pattern. If expanded further the complete method could be used to build three dimensional patterns that have or have not a pre-determined grid. The building process would have to consider the relation of 4 cells to begin rather than 3 and at each combination of one cell, it would be placed in relation to three others.

Conclusions

The process described in this paper should not be considered only as a technique as it does have wider theoretical implications in terms of design. The implication is that individual clients do have expressible values in terms of the environmental pattern in which they live. If the clients can understand more clearly their needs in these terms, then the architect can assume the role of educator and the built form becomes responsive to individual and expressive needs.

In the case of two people requiring an architect to produce a house the problem could be sequential. Firstly each client would operate with the system to find the pattern that reflected their values. Then the problem would be to find out what the area of compromise would be and to select a pattern. At this point the designer would continue the process to find a solution by either re-educating the clients or merely expressing the pattern in building form.

In any of the situations discussed, the decision process is made in an observable manner and can become a significant area of study, especially in preferrence shift and decision making. Without a method of observing the process this research could not be initiated with any degree of confidence.

Notes

1) The authors wish to thank Professors G.N. Soulis and V.K. Handa for their general criticism of this work which is contained as a section in the general article. Frew, R.S. The Nature of Preference Shift in Building Design, University of Waterloo, 1970 and a forthcoming PH D. dissertation.

2) Read, R.C. Contributions to the Cell Growth Problem Vol 14 No. 1 pp 1 - 20, Canadian Journal of Mathematics. 1962.

3) Lunnon has graphically generated all animals for n = 1----10 and has indicated in a letter the magnitude of the n = 20 case. A number of articles by Lunnon dated 1969 and 1970 are of considerable interest.

4) Klarner has produced a number of articles on the subject. The most interesting in terms of this project would be Bouwkamp, C.J. and D.A. Klarner, Packing a Box With Y - Pentacubes, Journal of Recreational Mathematics Vol 3 No.1 1970.

5) Stephenson, William, The Study of Behaviour Q - Technique and its Methodology, University of Chicago Press 1953.

6) Frew, R.S. An Introduction to Systems Architecture, thesis, University of Waterloo 1967 this work is summarized in Frew, Handa and Soulis. An Approach to Physical Environment Problems in proceedings 14th international conferrence of management Science. TIMS. Mexico City 1967.

7) Harmon, Harry, Modern Factor Analysis University of Chicago Press 1967.

SP-1 -- A COMPUTERIZED MODEL FOR STORE PLANNING

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Abstract

This paper discusses the design process used by department store planners to lay out "block plans" of the interiors of large department stores, and describes a recently-developed spatial allocation computer program SP-1 (Store Planning - One), which automates a portion of this process.

SP-1 employs a heuristic procedure to locate departments within a defined store perimeter. It was designed to be used in an architect's office by store planners and, therefore, has easy to use input and output formats.

Unlike most previously developed spatial allocation procedures, SP-1 focuses on a specific, unique field of application, rather than attempting to deal with a wide range of situations. Thus, although the program is limited in its scope of application, it deals particularly effectively with the job for which it was "tailor-made".

Store Planning Procedure

Store Planning is a unique field of architecture that deals with the design of the interiors of department stores. This includes all types and sizes of stores from the smallest boutiques to multi-level buildings and shopping centers. It is a field that through the years has become rather specialized, and there are many architects and designers who work entirely in this field.

The normal design procedure that store planners use begins with meetings with the client to discuss division and department space requirements, the kinds of spatial arrangements that would be best, and the design of the building itself, if it has not already been designed. Figure 1 illustrates this procedure. Store planners are occasionally involved in the design of the building exterior or perimeter walls, although they are most often consulted for ideas about such things as bay spacings and the location of stairs, escalators and loading docks. These requirements are then organized into a final list of area and organizational requirements. The store planner then prepares a set of alternative "block plans", showing the approximate locations of each division or group of sales areas within the building perimeter. Figure 2 is an example of a block plan of one floor of a May Company Department Store planned by Morganelli-Heumann and Associates, which is now under construction. The configuration of these block plans are determined by client information and the experience and knowledge of the store planner. The final "block plan" which is agreed upon by the client is usually the result of many presentations and resulting revisions.

This final plan is reviewed with the client, and then the individual sales areas, stock areas, and aisle locations are laid out, in what is called a "fixture plan". Figure 3 is the fixture plan of the same department store shown in Figure 2.

Maximization of Profit

The primary objective which becomes apparent soon in this analysis of the store planning design procedure is the maximization of the store's profit through careful sizing and placement of the various departments in the most strategic locations and proximity to each other. As an example, it is assumed that a potential customer who is considering purchasing a stove or refrigerator probably has some idea about the location in the store where he will find that particular department. Consequently, there is no need to put that department near an entrance to the store or adjacent to a high traffic area. This customer will probably not mind walking back to a rear corner of the basement. In fact, he would probably automatically think to look there for major appliances. On the other hand, a woman who "goes shopping" on a Saturday afternoon may decide to purchase a dress, and then on impulse purchase a scarf or necklace from the women's accessory department which has been strategically placed next to women's dresses, in the most heavily trafficked area of the store. Consequently, the consideration of impulse buying begins to enter the image we have of a well-designed department store.

Adjacency of Departments

Another obvious consideration in the design of a department store is the simple notion of adjacency of departments. As an illustration of this idea, some store planners might think a

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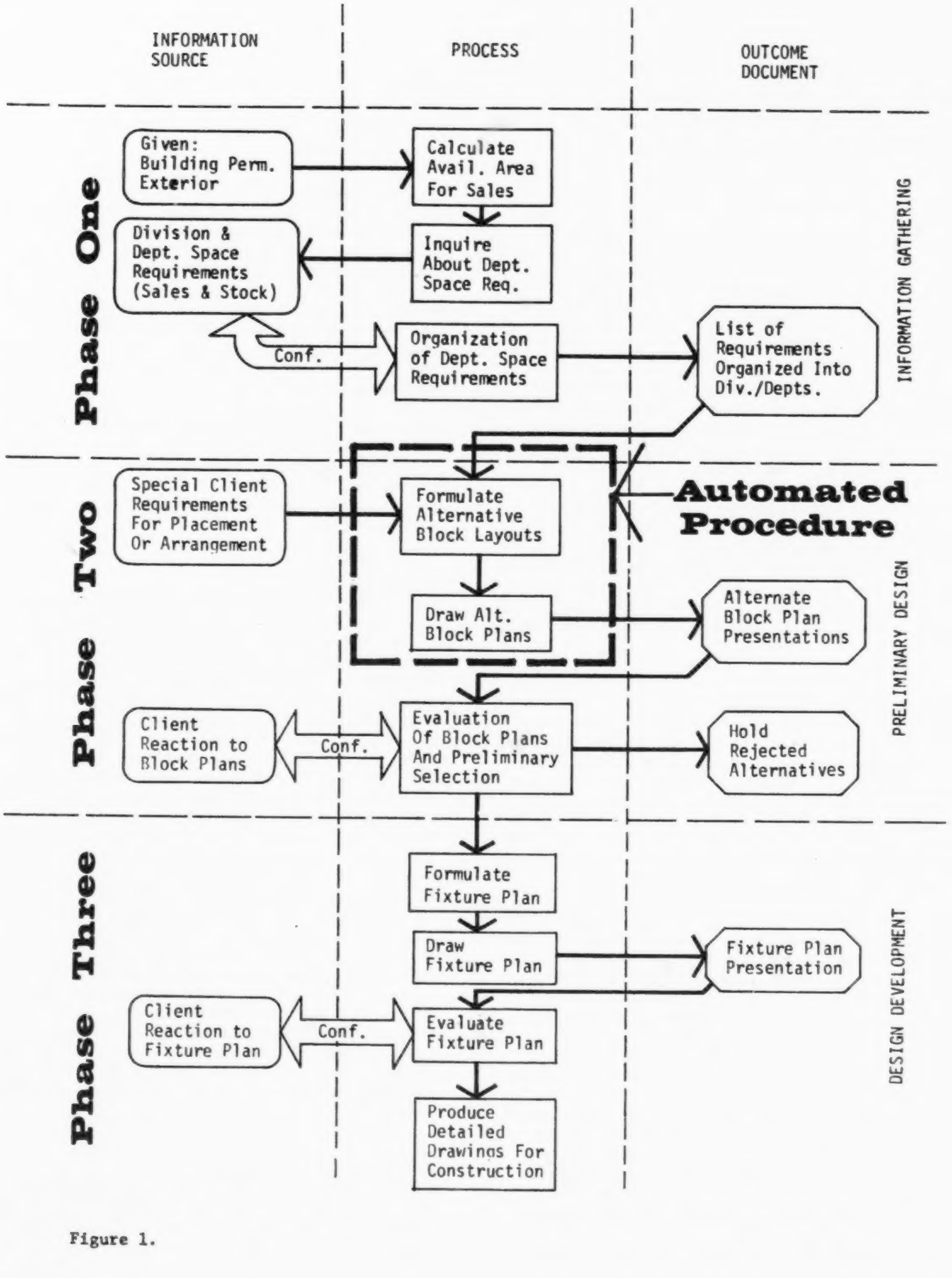

INFORMATION SOURCE
PROCESS
OUTCOME DOCUMENT
Phase One
Given: Building Perm. Exterior
Calculate Avail. Area For Sales
Division & Dept. Space Requirements (Sales & Stock)
Inquire About Dept. Space Req.
Conf.
Organization of Dept. Space Requirements
List of Requirements Organized Into Div./Depts.
INFORMATION GATHERING
Phase Two
Automated Procedure
Special Client Requirements For Placement Or Arrangement
Formulate Alternative Block Layouts
Draw Alt. Block Plans
Alternate Block Plan Presentations
PRELIMINARY DESIGN
Client Reaction to Block Plans
Conf.
Evaluation Of Block Plans And Preliminary Selection
Hold Rejected Alternatives
Phase Three
Formulate Fixture Plan
Draw Fixture Plan
Fixture Plan Presentation
DESIGN DEVELOPMENT
Client Reaction to Fixture Plan
Conf.
Evaluate Fixture Plan
Produce Detailed Drawings For Construction

Figure 1.

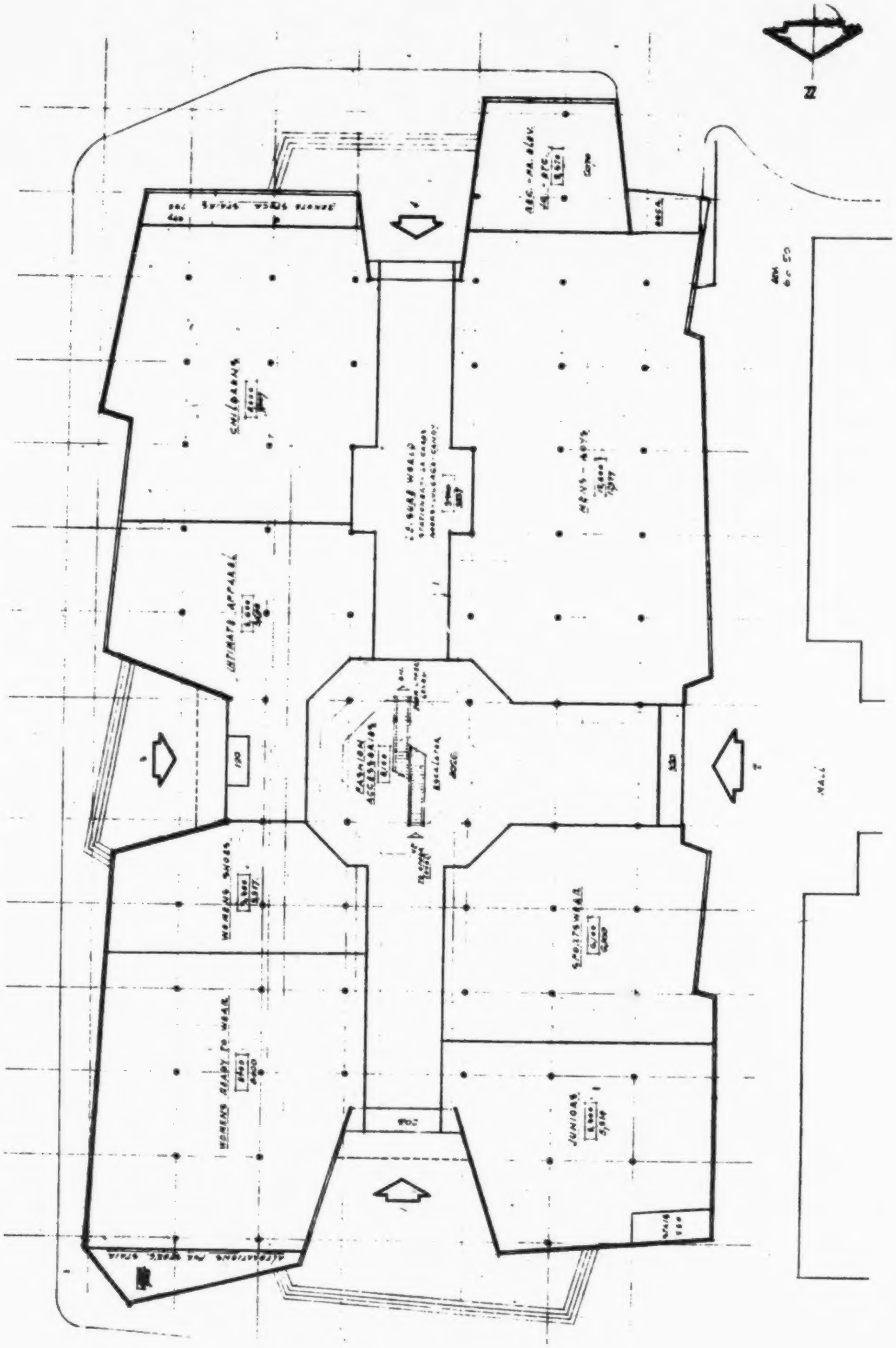

CHILDRENS
INTIMATE APPAREL
MENS - BOYS
FASHION ACCESSORIES
ESCALATOR
WOMENS SHOES
WOMENS READY TO WEAR
SPORTSWEAR
JUNIORS
MALL
N

Figure 2.

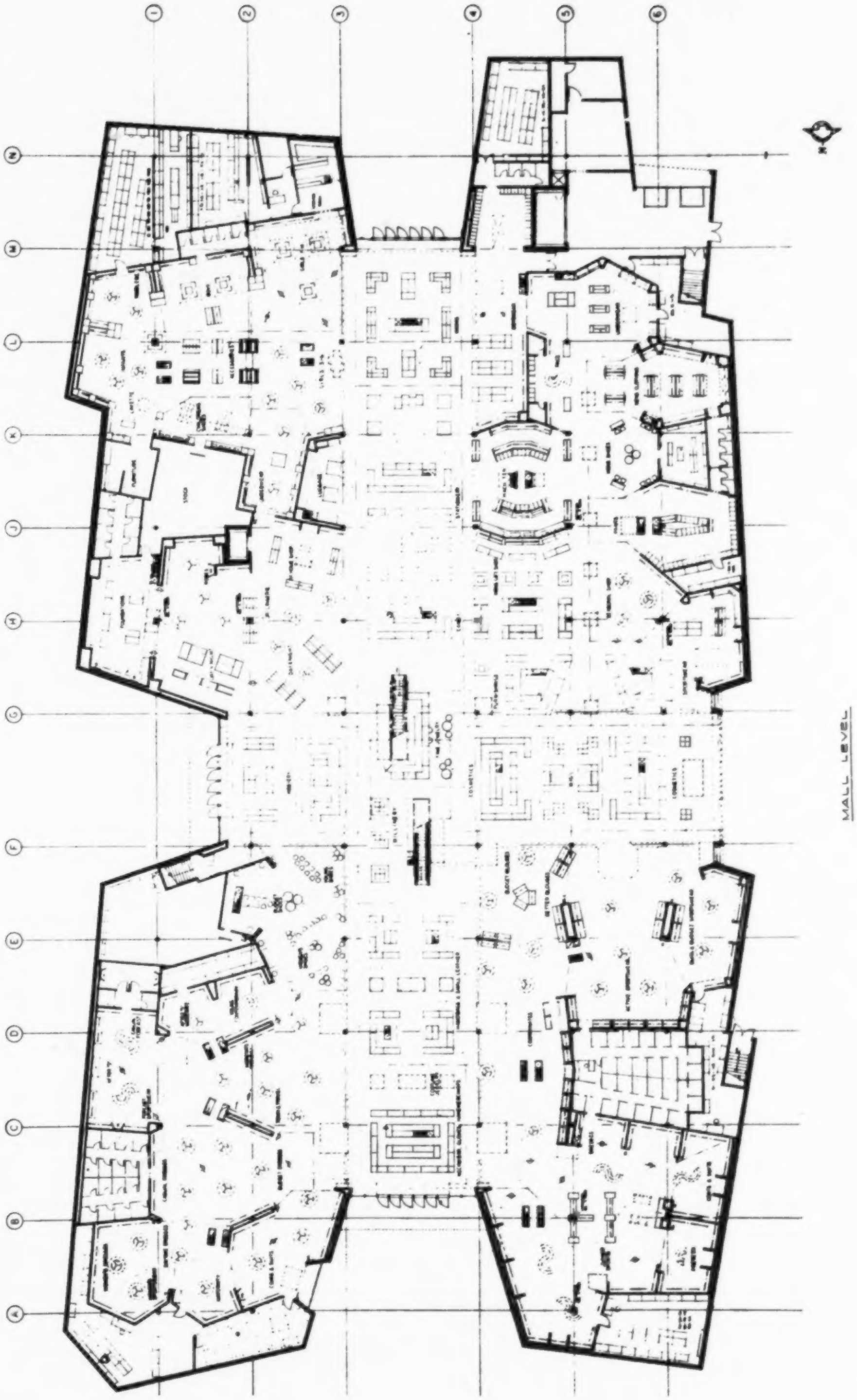

1
2
3
4
5
6
N
M
L
K
J
H
G
F
E
D
C
B
A
MALL LEVEL

Figure 3.

good design solution includes placing men's shirts and ties next to boys' clothing, while another would put men's shirts and ties next to women's accessories, reasoning that wives buy most of men's ties. Consequently, our computerized model should be able to consider such basic adjacency relationship specifications as defined by the store designer. Similar to department adjacency, but a slightly differing concept, is that of distance relationships between departments. If it is decided that two departments should be near one another, but not necessarily touching, then a simple adjacency criterion is not sufficient. It would seem then, that for our list of design objectives to be complete, we need to specify not only those departments which must be physically adjacent, but also those that should be near to each other, but not necessarily touching. For example, since shoe departments have a very large turnover of stock, a well-designed store will have its shoe department <u>near</u> the receiving and loading dock. However, it is certainly not necessary for the shoe department to be physically touching the loading area.

Consequently, at this point we have two considerations. The first and most obvious is adjacency or distance between areas on the floor. The second is the relationship between impulse purchasing and preconceived purchasing. When these two ideas are combined, the implications become more complex. For example, we could use "target departments" to draw customers through the store past the impulse departments.

The portion of the store planning design procedure which has been automated by SP-1 is noted in Figure 1. This automated procedure includes primarily the preliminary "block planning" procedure, but it may also be of use to assist the designer in the more refined layout procedure by isolating a particular section of the floor and blocking out individual departments in that area.

It was found that store planners were able to fairly adequately define their design objectives by specifying the following:

a. Areas of departments and divisions.

b. Interrelationships between departments and divisions (expressed as a numerical value).

c. The perimeter of the building.

d. Preassignment of certain areas within the perimeter.

Given this information, it is possible to model department store "block planning" as a quadratic assignment problem, and to solve it by using any one of many available algorithms. SP-1 is essentially a set of input-output routines which enable a store planner to quickly and easily specify his objectives, translating this information into a form where it may be used as input to a quadratic assignment procedure and prints the results in an immediately useful form. The results illustrated in this paper were produced using a modified implicit enumeration procedure for solution of the quadratic assignment problem. (1)

Preparation of Input

The primary consideration in designing the input and output formats of SP-1 was that it be as simple and easy to use as possible. To begin with, certain essential information is required, such as the date and name of the project. The scale of the floor plan to be produced is then defined. Next are the numerical values assigned to the various interaction values. See Figure 4.

```
NOVEMBER 29, 1971

MAY COMPANY - SCHEME NO. 1

FOR PURPOSES OF SCALE ONE UNIT OF SPACE ON THE FLOOR
PLAN CONTAINS   25 SQUARE FEET.  IT IS AN AREA    5 FEET BY    5 FEET.

THE LAYOUT SPECIFICATION FOR THIS RUN IS:   DIVISIONS ONLY.

LAYOUT MODULE SPECIFICATION = **

INTERACTION VALUES:

     8  = ABSOLUTE
     4  = ESSENTIAL
     2  = IMPORTANT
     1  = OPTIONAL
     0  = UNIMPORTANT
    64  = SAME AREA
    -8  = NEGATIVE INTERACTION

BUILDING PERIMETER DISTANCES AND DIRECTIONS.

   10E  70E   5S  70E  10S   5E  70S   5E  10S  40E   5N   5E  10N   5E
   15N   5E  15N  50E   5S  30E  15N  15E   5S  25E   5S  35E  75S  20W
   35S  20E   5S  35E  65S  20W   5S  15W  25S  30W   5N  15W   5S  60W
    5S  55W   5N   5W   5N  50W   5S   5W   5S  25W   5N  20W   5S  95W
   65N   5W  25N  15E   5N  15E   5N  10E  60N  10W   5N  15W   5N  10W
    5N  10W  10N   5W  25N   5W  25N   5E   5N   5E   5N   0    0    0
```

Figure 4.

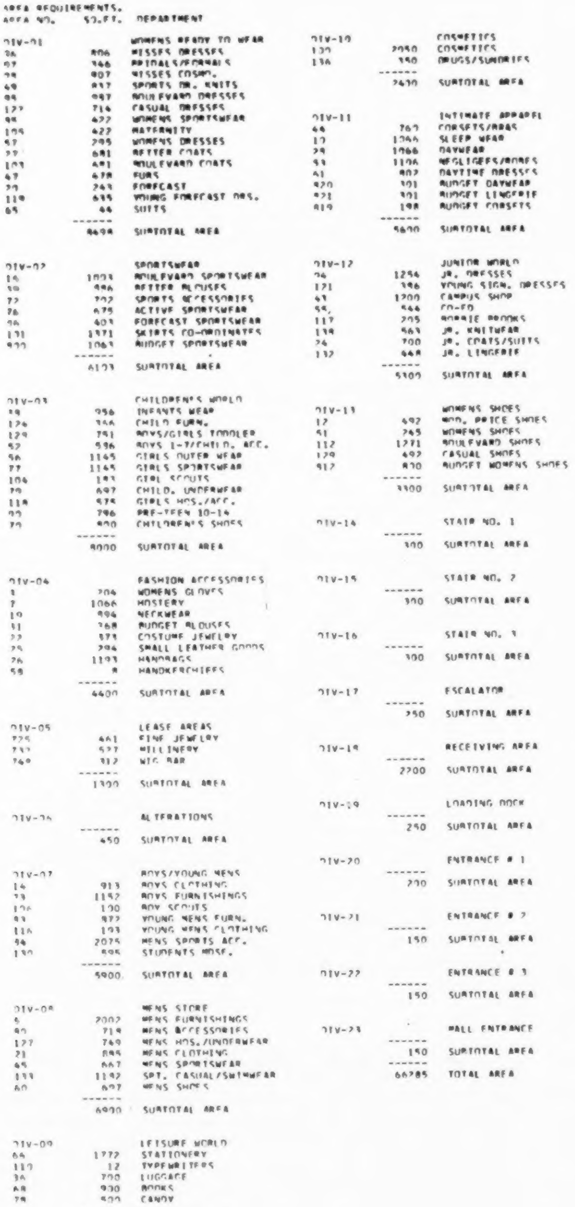
The areas which are to be assigned within the defined perimeter are listed, and they can be further organized into divisions as the example in Figure 5.

The interactions between areas are input in the form of a matrix. See Figure 6. We have found that results improve if the matrix is relatively sparse.

Building Perimeter and Preassigned Departments

By far the most frustrating and time-consuming part of data preparation in previous space allocation computer programs has been preassigning areas within the building and excluding outside areas or indentations in the building perimeter. This is handled quickly and easily in SP-1 by describing their exact perimeter beginning from the upper left corner of the building and producing a list of distances and directions which completely describe the area in a clockwise manner.

The building perimeter description is shown in Figure 4, and the preassigned areas within the building perimeter are shown in Figure 7.



```
AREA REQUIREMENTS.
AREA NO.     SQ.FT.   DEPARTMENT

DIV-01                WOMENS READY TO WEAR
36              806   MISSES DRESSES
97              366   BRIDALS/FORMALS
39              807   MISSES COSMO.
49              837   SPORTS DR. KNITS
89              987   BOULEVARD DRESSES
122             714   CASUAL DRESSES
98              422   WOMENS SPORTSWEAR
105             422   MATERNITY
57              295   WOMENS DRESSES
22              681   BETTER COATS
103             481   BOULEVARD COATS
47              678   FURS
29              263   FORECAST
119             635   YOUNG FORECAST DRS.
65               44   SUITS
             ------
               8698   SUBTOTAL AREA

DIV-02                SPORTSWEAR
19             1093   BOULEVARD SPORTSWEAR
30              986   BETTER BLOUSES
72              292   SPORTS ACCESSORIES
76              675   ACTIVE SPORTSWEAR
96              403   FORECAST SPORTSWEAR
131            1371   SKIRTS CO-ORDINATES
922            1063   BUDGET SPORTSWEAR
             ------
               6123   SUBTOTAL AREA

DIV-03                CHILDREN'S WORLD
39              956   INFANTS WEAR
126             366   CHILD FURN.
129             751   BOYS/GIRLS TODDLER
52              596   BOYS 1-7/CHILD. ACC.
56             1145   GIRLS OUTER WEAR
77             1145   GIRLS SPORTSWEAR
104             183   GIRL SCOUTS
79              697   CHILD. UNDERWEAR
118             578   GIRLS HOS./ACC.
99              796   PRE-TEEN 10-14
70              800   CHILDREN'S SHOES
             ------
               9000   SUBTOTAL AREA

DIV-04                FASHION ACCESSORIES
1               204   WOMENS GLOVES
7              1066   HOSIERY
19              994   NECKWEAR
31              368   BUDGET BLOUSES
22              373   COSTUME JEWELRY
25              294   SMALL LEATHER GOODS
26             1193   HANDBAGS
59                8   HANDKERCHIEFS
             ------
               4400   SUBTOTAL AREA

DIV-05                LEASE AREAS
725             461   FINE JEWELRY
732             527   MILLINERY
760             312   WIG BAR
             ------
               1300   SUBTOTAL AREA

DIV-06                ALTERATIONS
             ------
                450   SUBTOTAL AREA

DIV-07                BOYS/YOUNG MENS
14              913   BOYS CLOTHING
33             1152   BOYS FURNISHINGS
106             190   BOY SCOUTS
93              872   YOUNG MENS FURN.
116             193   YOUNG MENS CLOTHING
94             2075   MENS SPORTS ACC.
130             505   STUDENTS HOSE.
             ------
               5900   SUBTOTAL AREA

DIV-08                MENS STORE
5              2002   MENS FURNISHINGS
90              719   MENS ACCESSORIES
127             769   MENS HOS./UNDERWEAR
21              895   MENS CLOTHING
45              667   MENS SPORTSWEAR
133            1192   SPT. CASUAL/SWIMWEAR
60              697   MENS SHOES
             ------
               6900   SUBTOTAL AREA

DIV-09                LEISURE WORLD
64             1772   STATIONERY
119              12   TYPEWRITERS
36              700   LUGGAGE
68              930   BOOKS
78              500   CANDY
             ------
               3994   SUBTOTAL AREA

DIV-10                COSMETICS
130            2050   COSMETICS
136             390   DRUGS/SUNDRIES
             ------
               2430   SUBTOTAL AREA

DIV-11                INTIMATE APPAREL
44              762   CORSETS/BRAS
17             1066   SLEEP WEAR
29             1966   DAYWEAR
33             1106   NEGLIGEES/ROBES
41              802   DAYTIME DRESSES
820             301   BUDGET DAYWEAR
821             301   BUDGET LINGERIE
819             198   BUDGET CORSETS
             ------
               5690   SUBTOTAL AREA

DIV-12                JUNIOR WORLD
34             1254   JR. DRESSES
121             396   YOUNG SIGN. DRESSES
43             1200   CAMPUS SHOP
55,             544   CO-ED
117             295   BOBBIE BROOKS
139             563   JR. KNITWEAR
24              700   JR. COATS/SUITS
132             448   JR. LINGERIE
             ------
               5300   SUBTOTAL AREA

DIV-13                WOMENS SHOES
12              492   MOD. PRICE SHOES
51              265   WOMENS SHOES
112            1271   BOULEVARD SHOES
129             492   CASUAL SHOES
912             830   BUDGET WOMENS SHOES
             ------
               3300   SUBTOTAL AREA

DIV-14                STAIR NO. 1
             ------
                300   SUBTOTAL AREA

DIV-15                STAIR NO. 2
             ------
                300   SUBTOTAL AREA

DIV-16                STAIR NO. 3
             ------
                300   SUBTOTAL AREA

DIV-17                ESCALATOR
             ------
                250   SUBTOTAL AREA

DIV-18                RECEIVING AREA
             ------
               2200   SUBTOTAL AREA

DIV-19                LOADING DOCK
             ------
                250   SUBTOTAL AREA

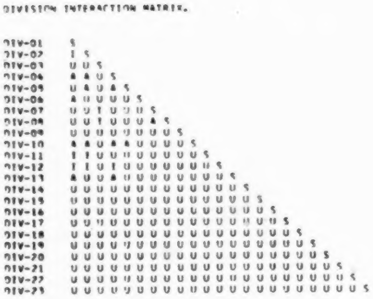
DIV-20                ENTRANCE # 1
             ------
                200   SUBTOTAL AREA

DIV-21                ENTRANCE # 2
             ------
                150   SUBTOTAL AREA

DIV-22                ENTRANCE # 3
             ------
                150   SUBTOTAL AREA

DIV-23                MALL ENTRANCE
             ------
                150   SUBTOTAL AREA
             ------
              66285   TOTAL AREA
```

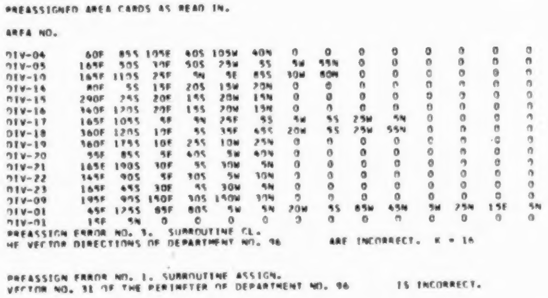
Figure 5.



```
DIVISION INTERACTION MATRIX.

DIV-01    S
DIV-02    I S
DIV-03    U U S
DIV-04    A A U S
DIV-05    U A U A S
DIV-06    A U U U U S
DIV-07    U U I U U U S
DIV-08    U U I U U U A S
DIV-09    U U U U U U U U S
DIV-10    A A U A A U U U U S
DIV-11    I I U U U U U U U U S
DIV-12    I I U I U U U U U U U S
DIV-13    A U U A U U U U U U U U S
DIV-14    U U U U U U U U U U U U U S
DIV-15    U U U U U U U U U U U U U U S
DIV-16    U U U U U U U U U U U U U U U S
DIV-17    U U U U U U U U U U U U U U U U S
DIV-18    U U U U U U U U U U U U U U U U U S
DIV-19    U U U U U U U U U U U U U U U U U U S
DIV-20    U U U U U U U U U U U U U U U U U U U S
DIV-21    U U U U U U U U U U U U U U U U U U U U S
DIV-22    U U U U U U U U U U U U U U U U U U U U U S
DIV-23    U U U U U U U U U U U U U U U U U U U U U U S
```

Figure 6.



```
PREASSIGNED AREA CARDS AS READ IN.

AREA NO.

DIV-04      60F   85S  105E   40S  105W   40N    0    0    0    0    0    0    0    0
DIV-05     165F   50S   30F   50S   25W    5S   5W  55N    0    0    0    0    0    0
DIV-10     165F  110S   25F    5N    5E   85S  10W  80N    0    0    0    0    0    0
DIV-14      80F    5S   15F   20S   15W   20N    0    0    0    0    0    0    0    0
DIV-15     290F   25S   20F   15S   20W   15N    0    0    0    0    0    0    0    0
DIV-16     340F  120S   20F   15S   20W   15N    0    0    0    0    0    0    0    0
DIV-17     165F  105S    5F    5N   25F    5S   5W   5S  25W   5N    0    0    0    0
DIV-18     360F  120S   10F    5S   35F   65S  20W   5S  25W  55N    0    0    0    0
DIV-19     360F  175S   10F   25S   10W   25N    0    0    0    0    0    0    0    0
DIV-20      55F   85S    5F   40S    5W   40N    0    0    0    0    0    0    0    0
DIV-21     165E  190S   30F    5S   30W    5N    0    0    0    0    0    0    0    0
DIV-22     345F   90S    5F   30S    5W   30N    0    0    0    0    0    0    0    0
DIV-23     165F   45S   30E    5S   30W    5N    0    0    0    0    0    0    0    0
DIV-09     195F   95S  150F   30S  150W   30N    0    0    0    0    0    0    0    0
DIV-01      45F  125S   85F   80S    5W    5N  20W   5S  85W  45N   5W  25N  15E   5N
DIV-01      15F    5N    0     0     0     0    0    0    0    0    0    0    0    0
PREASSIGN ERROR NO. 3.  SUBROUTINE CL.
HE VECTOR DIRECTIONS OF DEPARTMENT NO. 96         ARE INCORRECT.  K = 16


PREASSIGN ERROR NO. 1. SUBROUTINE ASSIGN.
VECTOR NO. 31 OF THE PERIMETER OF DEPARTMENT NO. 96        IS INCORRECT.
```

Figure 7.

Output of SP-1

The output of SP-1 is presented in two ways. The first (Figure 9) is the actual matrix showing the departments as numbers. The output is also shown as a line drawing which is taken from the numbered matrix. Figure 8 shows the same May Company Department Store as shown in Figures 2 and 3. This drawing is done on a high-speed printer and is, therefore, not to an exact scale. However, if the unit size chosen is 5 feet by 5 feet, as in the case of the department stores illustrated, it is approximately 1/16" = 1' 0".

Actual Use of the Computer Model

The ease of changing preassignments and the building perimeter give SP-1 the capability of presenting to the store planner and his client a wide variety of "block plans" in a short period of time. To illustrate this point, Figures 10 and 11 illustrate two recent layouts of a different May Company Department Store. The required areas to be assigned and the interaction values were essentially the same as the previous example. These two examples, which were part of a series of five different schemes,

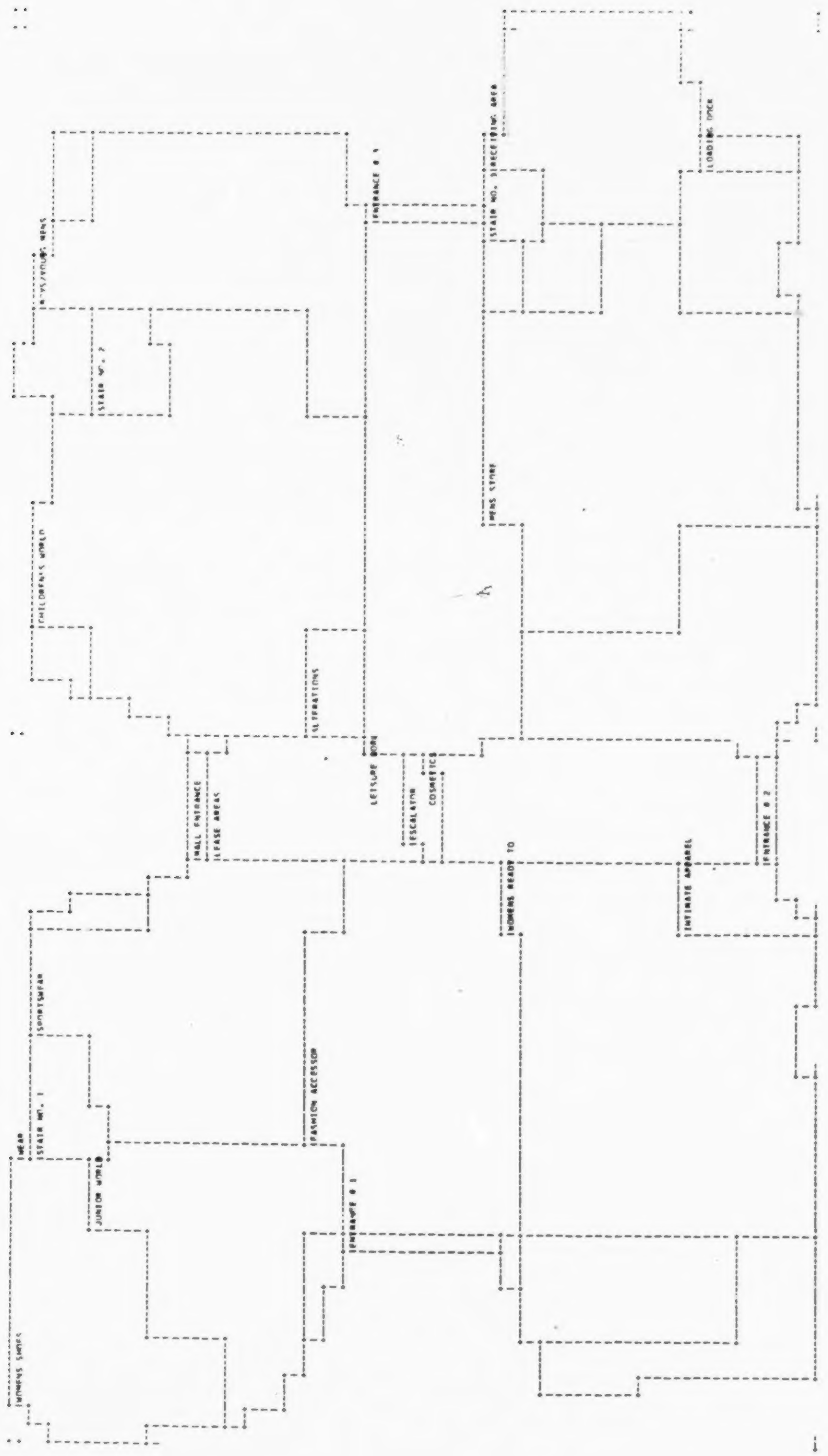

WOMENS SHOES
WEAR
STAIR NO. 1
SPORTSWEAR
JUNIOR WORLD
FASHION ACCESSOR
ENTRANCE # 1
MALL ENTRANCE
LEASE AREAS
LEISURE WORL
ESCALATOR
COSMETICS
WOMENS READY TO
INTIMATE APPAREL
ENTRANCE # 2
CHILDREN'S WORLD
STAIR NO. 2
BOYS/YOUNG MENS
ALTERATIONS
ENTRANCE # 3
MENS STORE
STAIR NO. 3 RECEIVING AREA
LOADING DOCK

Figure 8.

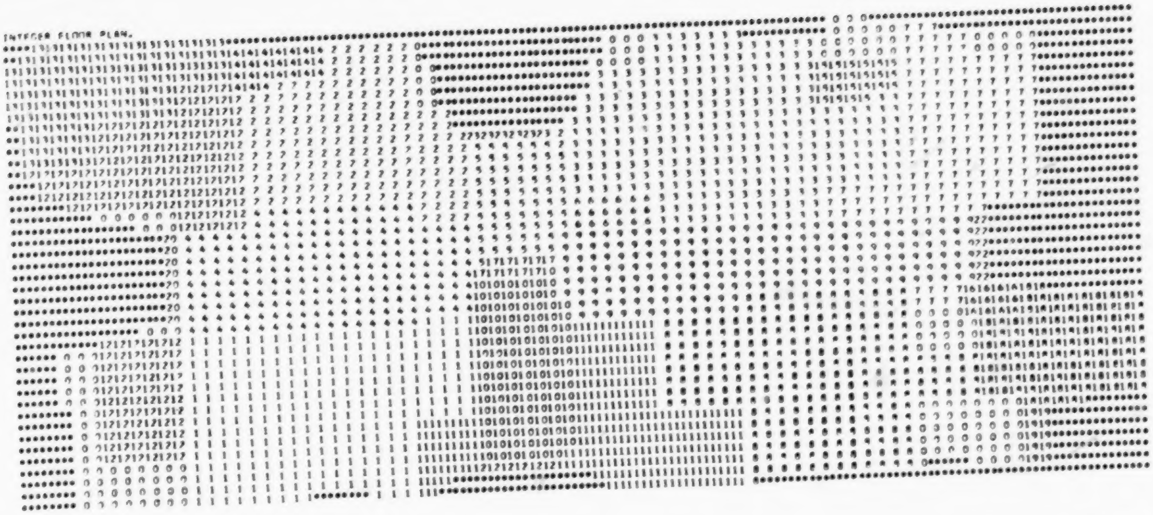

INTEGER FLOOR PLAN.

Figure 9.

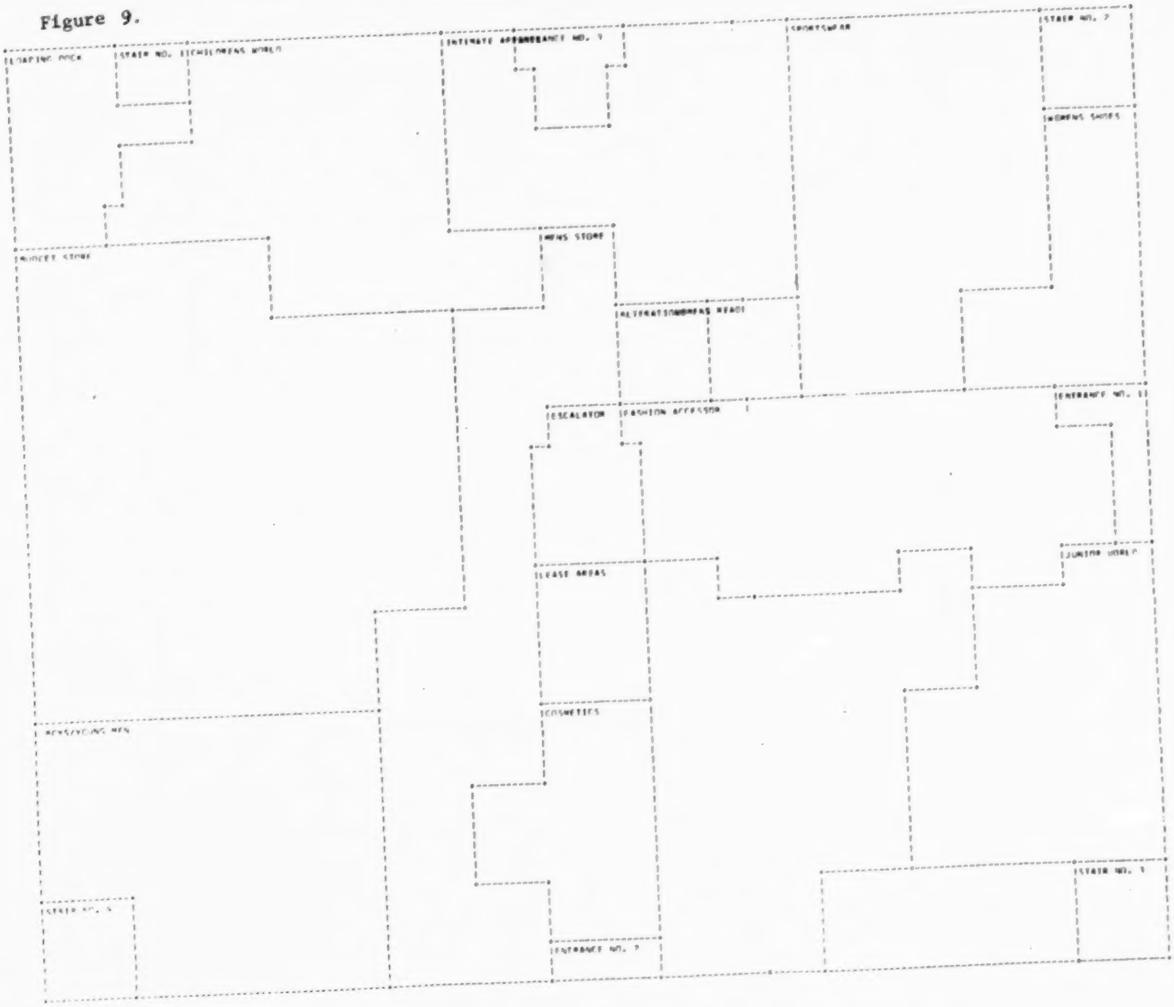

LOADING DOCK
STAIR NO. 1
CHILDRENS WORLD
INTIMATE APP
ENTRANCE NO. 3
SPORTSWEAR
STAIR NO. 2
WOMENS SHOES
BUDGET STORE
MENS STORE
ALTERATION
WOMENS READ
ESCALATOR
FASHION ACCESSOR
ENTRANCE NO. 1
LEASE AREAS
JUNIOR WORLD
COSMETICS
BOYS/YOUNG MEN
STAIR NO. 5
ENTRANCE NO. 2
STAIR NO. 3

Figure 10.

had several preassigned areas. The loading dock, stairways and entrances were preassigned, as well as the three selling departments: fashion accessories, lease areas and cosmetics. In Figure 11, the budget store was preassigned, as well as women's ready-to-wear.

Initial indications as to the usefulness of SP-1 are that it will be an extremely useful design tool, and it will actually reduce the time required to come up with a "block plan". As store planners become more proficient in the use of SP-1, they will be able to produce more alternatives and will be able to spend more of their time "evaluating alternatives" rather than shuffling around area square footages. Hopefully, then, they will be able to devote more of their time to creating innovative new schemes, which will improve the state of their art.

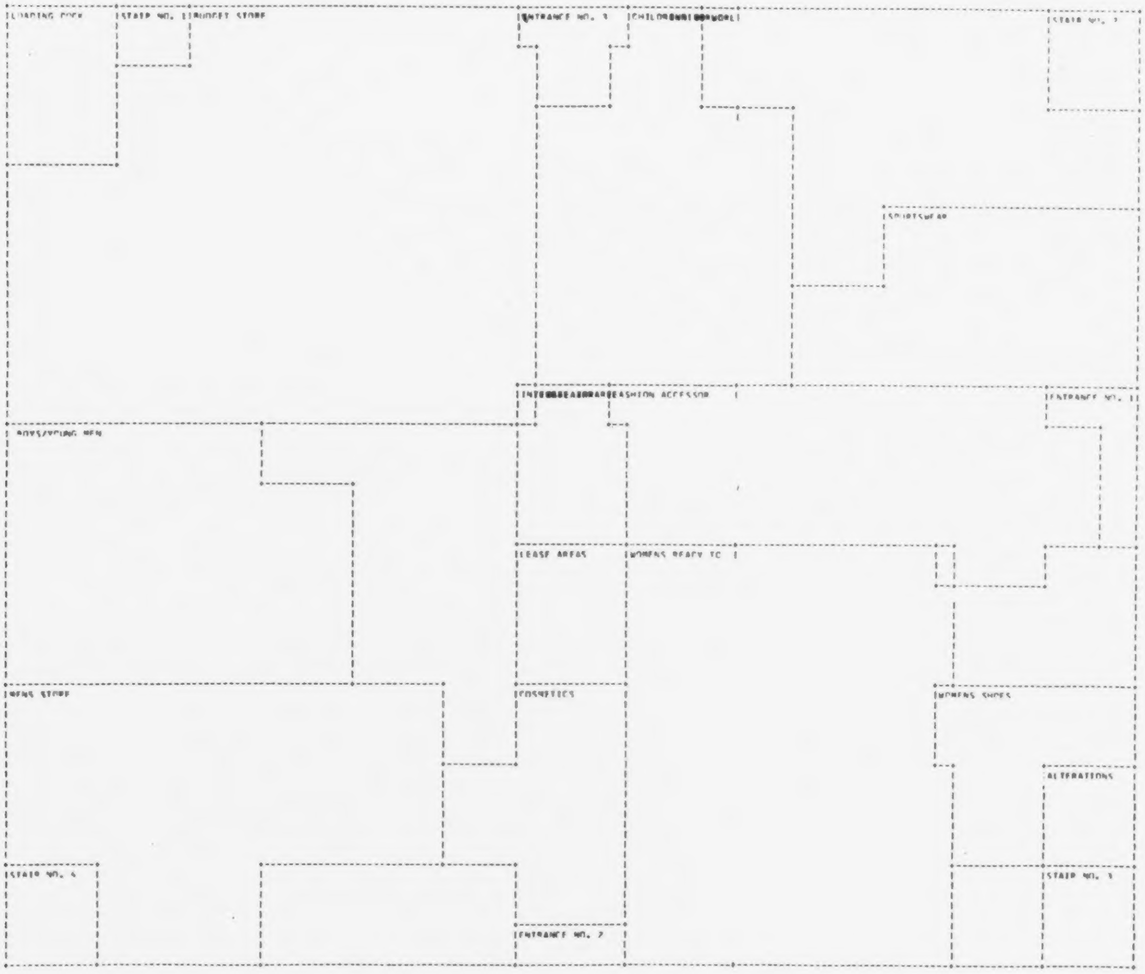

LOADING DOCK
STAIR NO. 1
BUDGET STORE
ENTRANCE NO. 3
CHILDRENS WORLD
STAIR NO. 2
SPORTSWEAR
FASHION ACCESSOR
ENTRANCE NO. 1
BOYS/YOUNG MEN
LEASE AREAS
WOMENS READY TO
MENS STORE
COSMETICS
WOMENS SHOES
ALTERATIONS
STAIR NO. 4
ENTRANCE NO. 2
STAIR NO. 3

Figure 11.

References:

1. Liggett, Robin S.
"Floor Plan Layout by Implicit Enumeration"
EDRA3-AR8, University of California,
Los Angeles, 1972

FLOOR PLAN LAYOUT BY IMPLICIT ENUMERATION

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Abstract

This paper presents an implicit enumeration approach to automated floor plan layout. Floor plan layout is viewed as a quadratic assignment problem in which indivisible facilities (for example, employees in an office) are to be assigned to fixed locations on a plan. One, and only one facility may be assigned to each location. An optimal plan is determined by the interactions between facilities to be located and the distances between locations on the plan.

Existing techniques for finding the optimal solution to the quadratic assignment problem have proved computationally infeasible for realistically sized problems. This paper presents an application to floor plan layout problems of an approximate algorithm for solving quadratic assignment problems which was developed by G.W. Graves and A.B. Whinston at the Graduate School of Management, UCLA [2]. Viewing the possible assignments as a combinatorial problem, the approach combines a general enumerative procedure with probability theory to form an implicit enumeration algorithm. The technique yields very good solutions, not necessarily optimal, but with realistic computation time.

Applications of the algorithm are given for layout problems in which interactions between facilities to be located can be considered meaningful criteria in determining a layout. A good example is the office layout problem in which interactions are a measure of communication cost between employees.

Introduction

In the past, one approach to automated floor plan layout has been the formulation as a quadratic assignment problem. In general, this type of problem consists of certain fixed locations to which a number of discrete facilities are to be assigned. One, and only one facility may be assigned to each location. The problem is to assign the facilities to locations in such a way as to minimize a total cost function.

Associated with each pair of locations is a 'distance' between locations representing cost of communication between the pair. This measure might be simply linear distance, but not necessarily so. Associated with each pair of facilities is an index of the 'traffic intensity' between two facilities. The cost of assigning a pair of facilities to a pair of locations is the product of the location distance times the facility traffic intensity. The cost for a total assignment, which is to be minimized, is the sum of these products for all location-facility pairs in the assignment.

The quadratic assignment problem was first applied by Koopmans and Beckman [3] for the solution of a plant location problem in which there were a number of sites to which various plants were to be assigned. The objective to be optimized was a function of the cost of shipping between sites and interaction effects resulting from cross shipments between plants.

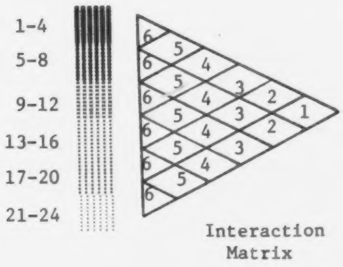
The floor plan layout problem can be modeled similarly using locations on the plan to correspond to plant sites and the spatial units to be located to correspond to the plants. Interaction weights between units can reflect communication, volume, cost, or any other desired variable.

As Koopmans and Beckman pointed out, the computational difficulties of solving a quadratic assignment problem have so far been insurmountable using existing techniques for even a small number of elements. This paper presents an application to floor layout problems of an approximate general algorithm for solving the class of quadratic assignment problems. The algorithm, which was developed by Graves and Whinston [2], yields very good solutions, though not necessarily optimal, but with realistic computation time. Viewing the possible assignments as a combinatorial problem, the approach combines a general enumerative procedure with probability theory to form an implicit enumeration algorithm.

An explanation of the algorithm along with computational results of applications of the method is presented. The algorithm is used for layout problems in which interactions between facilities to be located can be considered meaningful criteria in determining a layout. The examples shown are office layout problems in which interactions are a measure of communication cost between employees.

Implicit Enumeration Approach

Consider the following abstract spatial relationship problem. We take a 6 X 4 square modular grid as shown in Figure 1. Twenty-four squares shaded in six different tones of grey (four squares of each tone) are to be located on the grid so as to minimize some objective function. The objection function is defined in such a way that the optimal locations produce a configuration giving smooth tonal transitions. The grey square formulation is an extremely good method for testing an assignment algorithm. Using graphic output, one can see immediately how close a particular algorithm comes to the optimal solution.



1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24

Locational Grid

Figure 1

This assignment problem can be viewed as a mapping of the set of grey squares (representing spatial units to be located) onto the set of possible locations. In this case there are 24 grey squares and 24 possible locations In general, we can consider the assignment of m spatial units to n locations where $m \leq n$.

Letting $S = \{i_1, i_2, \ldots, i_m\}$ be the set of spatial units to be located and $R = \{j_1, j_2, \ldots, j_m\}$ be the set of possible locations, a particular map ρ or solution vector can be represented in the following form:

$$\rho = \begin{pmatrix} i_1, & i_2, & \ldots & i_k, & \ldots & i_m \\ j_1, & j_2, & \ldots & j_k, & \ldots & j_m \end{pmatrix}$$

In this solution spatial unit i_k has been assigned to location j_k which we represent in notation form as $\rho(i_k) = j_k$.

One possible solution to the grey square problem is shown in Figure 2. Using the above mapping technique, the solution can alternatively be represented in the following manner:

POSITIONS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SQUARES	10	4	16	11	17	5	18	20	1	15	12	21	22	6	13	7	14	2	23	19	3	24	8	9

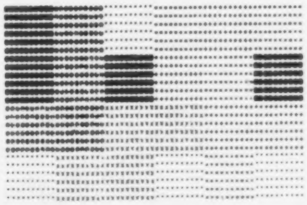


Figure 2

For a particular assignment problem there are n! possible maps (solution vectors), each characterized by the assignment of the elements in S to the elements in R. This type of problem is a 1-1 mapping in which each element in S is assigned to a unique element of R.

The quadratic assignment problem then consists of selecting from among the set of possible maps that which minimizes some objective function. In the grey square problem, the objective represents a function of distance between locations and interaction weights between squares to be located. Interaction weights are based on the separation of squares on the grey scale (Figure 1). For example, squares of the same tone interact with a weight of 6 while squares at opposite ends of the scale have an interaction weight of one.

Using the mapping approach, the general problem of assigning m units to n locations can be formulated as follows:

i = spatial unit to be located

j = possible location

a_{ij} = fixed cost of assigning element i to location j

$q_{i_1 i_2}$ = interaction between spatial unit i_1 and spatial unit i_2

$c_{j_1 j_2}$ = distance measure from location j_1 to location j_2.

Then the quadratic assignment problem can be stated as

$$\min_{\rho} \sum_{i} a_{i\rho(i)} + \sum_{i_1}\sum_{i_2} q_{i_1 i_2}\, c_{\rho(i_1)\,\rho(i_2)}.$$

A solution to the problem could be obtained by enumerating all the possible maps and calculating the value of the objective function for each. Since this is impractical, an enumeration scheme which excludes large numbers of possible solutions from consideration is used. These solutions are said to be implicitly enumerated.

The enumerative procedure is thought of as an n-stage decision problem, in which at the kth stage, we must decide which spatial unit to assign to which location. In this application, the important element of the algorithm is this selection of the next unit to assign. Using probability calculations, we can make predictions about the cost (in terms of the objective function) of assigning elements at each step. This enables us to choose the assignment which seems most likely to lead to an optimal solution. Although this method does not guarantee optimality, a very good solution is produced. Such a probability scheme is the basis of the implicit enumeration approach used here.

Figure 3 shows a solution of the grey square placement problem using the implicit enumeration algorithm. The step by step assignments are given, and it can be seen that in this case the optimal placement is achieved by the algorithm.

Enumerative Scheme

The enumerative scheme is a systematic method for generating possible solution vectors. It must indicate what solutions have already been considered and which ones remain to be examined. A flow diagram of the procedure used here is shown in Figure 4.

This enumerative scheme generates all feasible maps if allowed to run to termination. In practice, due to the use of probability in the selection of next element to assign, the first mapping obtained is accepted as a good solution allowing the scheme to be terminated.

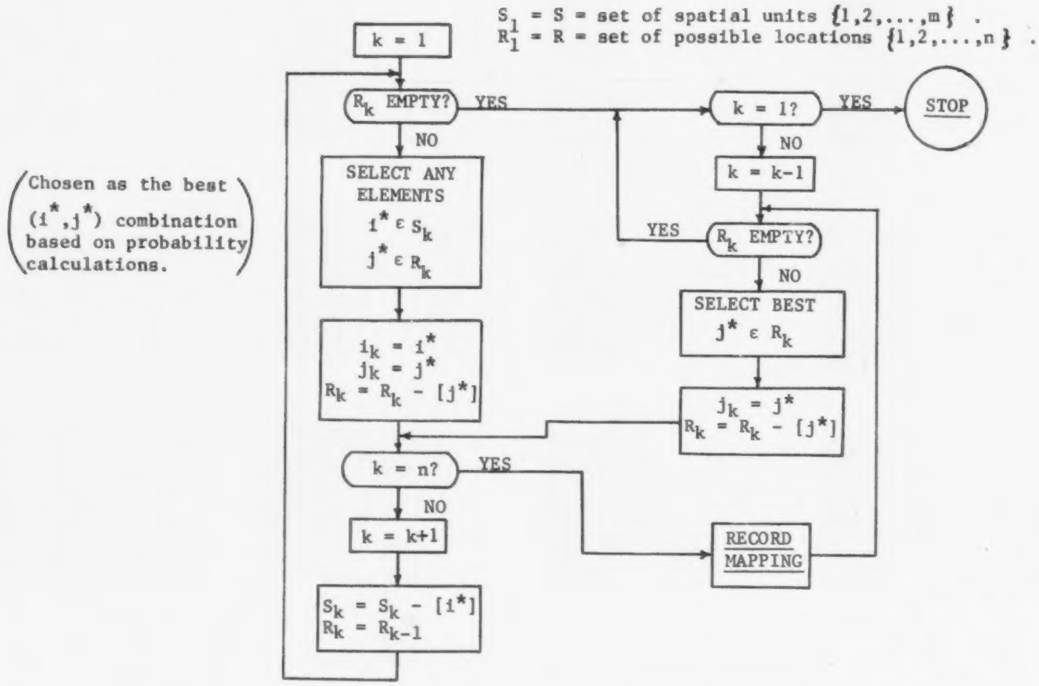
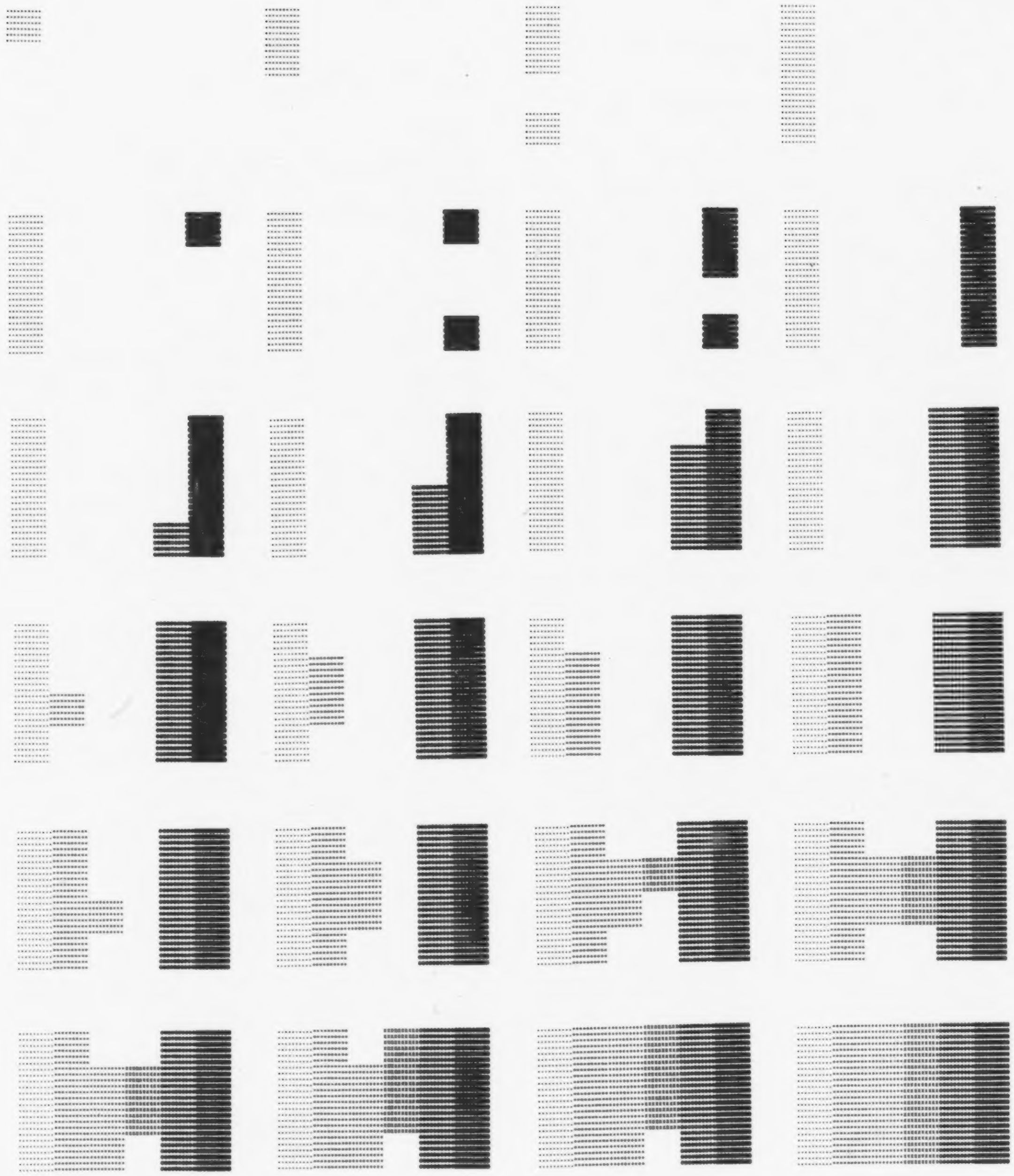

S_1 = S = set of spatial units {1,2,...,m} .
R_1 = R = set of possible locations {1,2,...,n} .
k = 1
R_k EMPTY?
YES
NO
SELECT ANY ELEMENTS $i^* \in S_k$ $j^* \in R_k$
(Chosen as the best (i^*,j^*) combination based on probability calculations.)
$i_k = i^*$ $j_k = j^*$ $R_k = R_k - [j^*]$
k = n?
k = k+1
$S_k = S_k - [i^*]$ $R_k = R_{k-1}$
k = 1?
STOP
k = k-1
SELECT BEST $j^* \in R_k$
$j_k = j^*$ $R_k = R_k - [j^*]$
RECORD MAPPING

Figure 4



Step by Step Solution to Grey Square Problem

Figure 3

Selection of Next Element to Assign

At the second step of the enumeration scheme we must decide which spatial unit to select and which location to assign to that unit. The effects of a particular assignment are twofold -- the immediate cost of assigning the unit and the restrictions this imposes on possible choices for future assignments. The potential future cost of an assignment due to these restrictions is the crucial factor. Since we can't enumerate explicitly all possible assignments to determine exact future costs, we use probability to make good predictions about the effects of a particular assignment.

The set of all possible solution maps can be represented by a decision tree as shown in Figure 5. Each node on the tree represents a possible assignment. Each path through the decision tree represents a possible solution (mapping) to the assignment problem. In this example n=4 and there are n! = 24 possible maps. Following the bottom path of the tree we get the following mapping:

POSITIONS	1	2	3	4
SQUARES	4	3	2	1

As we move through the tree, at each decision node we would like to choose that branch (make that assignment) which puts us on the right track to an optimal solution. One method of making a choice, providing we possess the necessary information, is to use the mean value of the objective function for the maps corresponding to the possible paths which can be taken from a particular node, and choose the fork which leads us to the lowest mean value. Choosing the branch with the lowest mean value does not, of course, guarantee that we will reach an optimal solution, but it is reasonable to expect that this must lead to some very good solutions.

We can calculate the expected value for the objective function by enumerating all the possible maps, calculating the objective for each, summing them and dividing by n! (the total number of possible maps). It is of course impractical to enumerate all maps, and the work needed in doing the computation would lead us directly to the optimal solution. It turns out, though, that the expected values can be determined explicitly without total enumeration. These expected values can then be used in selecting a good solution.

We can calculate the sum of the objective functions corresponding to all possible maps by summing over all possible assignments as follows:

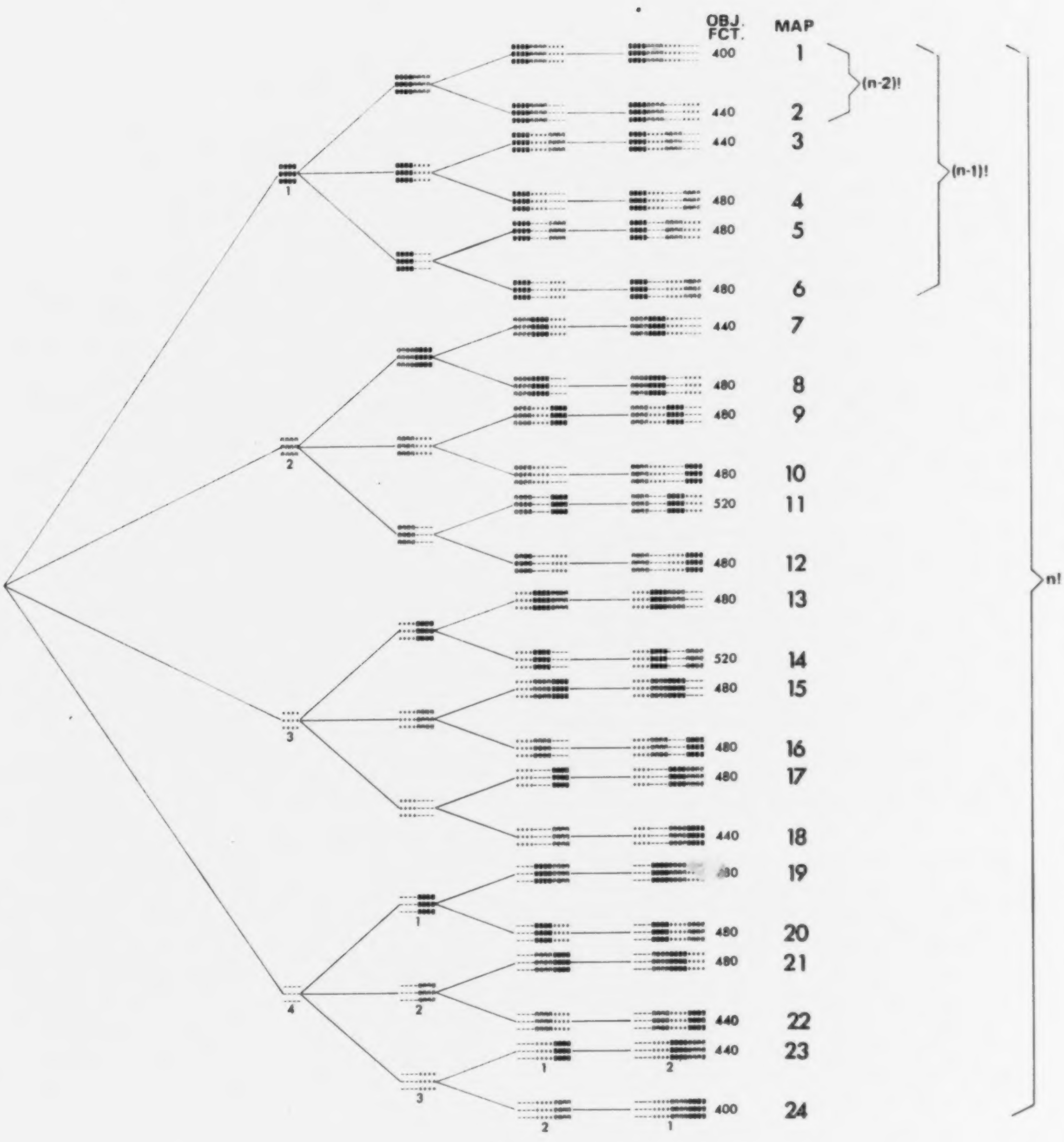
$$SUM = \sum_{i=1}^{m} \sum_{j=1}^{n} a_{ij} + \sum_{i_1=1}^{m} \sum_{j_1=1}^{n} \sum_{i_2=1}^{m} \sum_{j_2=1}^{n} q_{i_1 i_2} \; c_{j_1 j_2}$$

Before any assignments have been made there are n! possible maps and since each is equally likely the probability of choosing any map is 1/n!. The expected value of the objective function for the assignment problem is then equal to SUM/n!.

After a first decision is made we have eliminated (n-1) branches of our decision tree from consideration. On the particular branch we have chosen there are now (n-1)! possible maps. Now the probability of choosing a map from this branch is (n-1)!/n! = 1/n. Similarly by making a second decision, we limit the number of maps to (n-2)! out of (n-1)! possibilities so the probability of a particular map is 1/(n-1). In general, the probability of choosing a particular map at the kth step in the decision process is 1/(n-k).

We can then calculate the expected value of the objective function for a k-partial map (defined as a map in which the first k elements are fixed and the remaining elements free) by summing over all possible assignments for the free elements, dividing by the probability of a k-partial map and adding the fixed portion of the objective function determined by the first k assignments. A more detailed description for calculating the mean value is given in Appendix A of Graves and Whinston, "An Algorithm for the Quadratic Assignment Problem." [2]

In general given (k-1) fixed units, (m-k) free units and (n-k) free locations for assignment, at any step k in the algorithm we can calculate the expected value of the objective function for each of the (n-k) possible combinations of fixing the kth spatial unit. In other words, looking at the kth decision node of the decision tree, we calculate the expected value of each of the (n-k) branches which are possible choices. The decision rule for selecting a particular assignment at step k is the value of the associated expected value. We choose the branch having the minimum expected value of the objective function.


OBJ. FCT.
MAP
400 1
440 2
440 3
480 4
480 5
480 6
440 7
480 8
480 9
480 10
520 11
480 12
480 13
520 14
480 15
480 16
480 17
440 18
480 19
480 20
480 21
440 22
440 23
400 24
(n-2)!
(n-1)!
n!
1
2
3
4
1
2
3
1
2
2
1

Decision Tree: n=4

Figure 5

Implementation

A program was implemented which incorporates the implicit enumeration algorithm. It follows the step by step assignment procedure in which the next element to be assigned is chosen on the basis of the expected value of the objective function.

Three matrices are required as input to the algorithm -- a matrix of interactions between spatial units to be located, a matrix of distances between locations on the plan, and a matrix giving fixed costs of assigning a particular element to a location. Normally for floor plan layout applications, the fixed cost matrix is taken as zero. It can be used, though, to limit the possible assignments of a particular unit by setting the fixed cost very high for locations to which the unit should not be assigned. The program also allows the preassignment of spatial units. This is desirable when the assignment of a unit to a particular location has been predetermined by other design considerations.

The enumeration is terminated at the completion of a feasible solution. Since the solution is not necessarily optimal, a heuristic which consists of trying all possible two-way switches between locations is then applied to this solution. This is an inexpensive method of obtaining solution improvements. When a feasible switch which lowers the value of the objective function is found, the exchange is accepted. The switch routine continues in cycle form until an entire cycle has been completed without a change in assignment.

The program is written FORTRAN IV and dimensioned presently to handle problems up to 130 units and locations. It has a 270 core requirement. Sample runs of the program were made on the IBM 360/91 computer. Computation times for running different size grey square problems are given in the following table.

n	cpu time
10	0.3 sec
30	1.31 sec
50	4.07 sec
70	9.8 sec
90	19.14 sec
110	31.87 sec
130	50.27 sec

COMPUTATION TIMES FOR GREY SQUARES PROBLEM

The program is designed so that when the interaction matrix is sparsely populated with interactions, which occurs in many real problems, units which do not interact with those already placed are not considered in the selection of the next unit to be assigned. This can decrease computation time considerably. Since there are no zero entries in the interaction matrix of the grey squares problem, the times in the table represent the maximum cpu time for a particular number of units. For the "trust" investments" layout problem described in a later section, 195 units were assigned in 45 seconds, since there were relatively few interactions.

Application to Office Landscape

A natural architectural application for the implicit enumeration algorithm is the office landscape problem. Office landscape focuses attention on the functional requirements of offices. Defining an office as a processing center for information, it can be thought of as resembling a factory where the task to be performed is information handling rather than materials handling. The efficiency of the office depends on the ease of flow and ease of communication of this information.

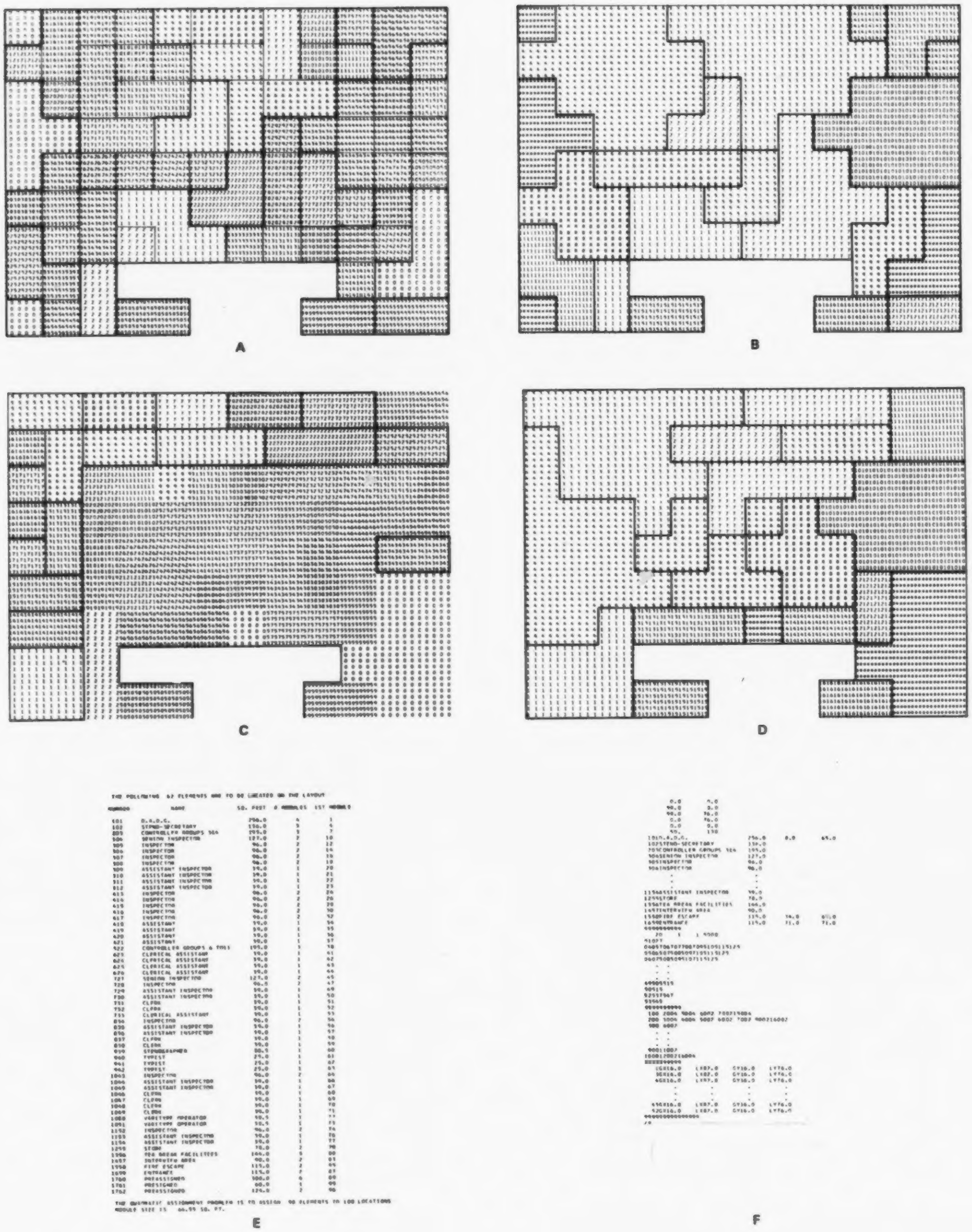
In designing an office landscape, a detailed study of all types of communication and relationships within the office is needed. This type of study provides the input for the matrix of interactions between the units to be located in the office. The implicit enumeration algorithm can be applied to the office landscape problem to determine the layout which will minimize the cost of communication based on such an interaction matrix.

The office landscape problem chosen as an example to demonstrate this application was an actual project handled by Gerd and Renate Block Architects, Melbourne, Australia. Available floor space for the office was a rectangle of approximately 100 x 80 feet, with some of the space filled with staircases and entrances. There were 54 employees (divided into eleven groups), plus additional equipment, a tea break facility, storeroom, and an interview area to be located.

A communication analysis of the office was made by the architects, and interaction matrices showing inter-group communication and intragroup communications were determined. Interactions were stated as either high, medium, or low. This data was translated into the required computer input and formed the basis for automated layout using the implicit enumeration program.

Input Data

Figure 6F is a sample of the input data for the office landscape problem. The data begins with a definition of the perimeter of the floor plan in terms of x and y coordinates. The coordinates are given in clockwise fashion beginning at the top left corner. The first coordinate is repeated to indicate completion of the perimeter.



Office Landscape

Figure 6

The desired module size in square feet is specified with a limit on the number of modules (in this case 130). Using this information, the program generates a map which divides the floor plan area into module locations and calculates the distances between module centroids to form the distance matrix. If the number of module locations generated exceeds the limit, the program iteratively increases the module size until an acceptable number is generated. In this example a module size of fifty square feet was originally requested, but the program increased it to 66.55 square feet, producing a total of 108 module locations.

Each spatial unit to be located is listed in the input data with its required square footage. A double numbering system can be used to indicate group memberships as well as individual unit numbers. The hundreds column represents the group number while the tens and ones columns refer to individual units. For example, 101 stands for group one, unit one. When no groups are involved only two digit numbers are used.

Based on the required square footage, the program calculates the number of modules assigned to each unit. If a unit is to be preassigned to a location, the coordinates of the location centroid must be specified. It is then assigned to that module or modules which are closest to the centroid.

Interactions are specified next in list form, so that only non-zero entries of the interaction matrix must be given. Interactions are entered on a scale from one to nine, but these values can be multiplied by weighting factors if desired. The following four weighting factors can be specified: the interaction weight between modules belonging to the same unit; a multiplicative weight for intra-group interactions; a multiplicative weight for inter-group interactions; and a value for entries of the fixed cost matrix.

Data cards specifying intra-group interactions and inter-group interactions are followed by data cards used for modifying the fixed cost matrix. It is normally initialized to zero, but costs can be generated by defining rectangular areas of the floor plan which are to have a high fixed cost for a particular unit. Rectangles are defined by placing limits on x and y coordinates for a particular unit. Any location module whose centroid falls within these limits is assigned a high fixed cost for the named unit.

Program Output

Figure 6E shows computer printout of the list of units to be located in the office landscape problem along with the square feet required and the number of modules the program has assigned to each unit. The quadratic assignment problem is to assign 98 units to 108 location modules. Unused space is for additional equipment, corridors, and landscaping. After the assignments are made, a computer printer map of the floor plan showing unit placements is generated. If groups are used in the problem, a second map showing group placement is also produced.

Figures 6A and 6B show the resulting layouts using interaction weights of 9, 7, and 5 for high, medium, and low intra-group relations, and 4, 2, and 0 for inter-group relations. This distinction was needed to ensure coherence of departments. No fixed costs were assumed for any unit-location combination, and only the entrance and fire escape were preassigned. Figure 7 shows the original inter-group interaction matrix and the intra-group matrices for groups three and seven. Circled elements in the matrices indicate interactions satisfied by the layout.

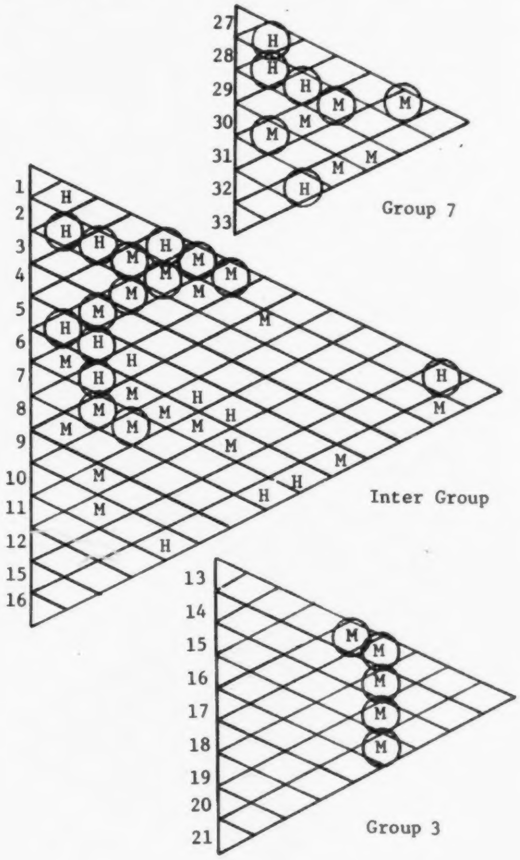


Figure 7

In determining the actual layout plan, other considerations besides the interactions had to be taken into account by the architects. In particular, a late addition to the brief required that the D.A.D.G. be located next to the fire escape. Also, he insisted on having his senior people located adjacent to the windows. Figures 6C and 6D show a layout plan conforming to these restrictions. The D.A.D.G. was preassigned to the lower left hand corner of the plan, and for each of the senior employees a fixed cost was placed on all location modules further than two modules from the windows. A number of computer runs were made to experiment with different values for the fixed cost matrix. Not until a value of 5000 was reached did the fixed cost sufficiently override the interactions to ensure all the senior people were located close to the windows.

Figure 8 shows the elements in the inter and intra-group interaction matrices which were satisfied under this plan. On the group level approximately the same number are satisfied as in the previous example, but intra-group relationships could not be maintained when the senior people were placed in the window positions. Two of the groups are even split into two separate parts.

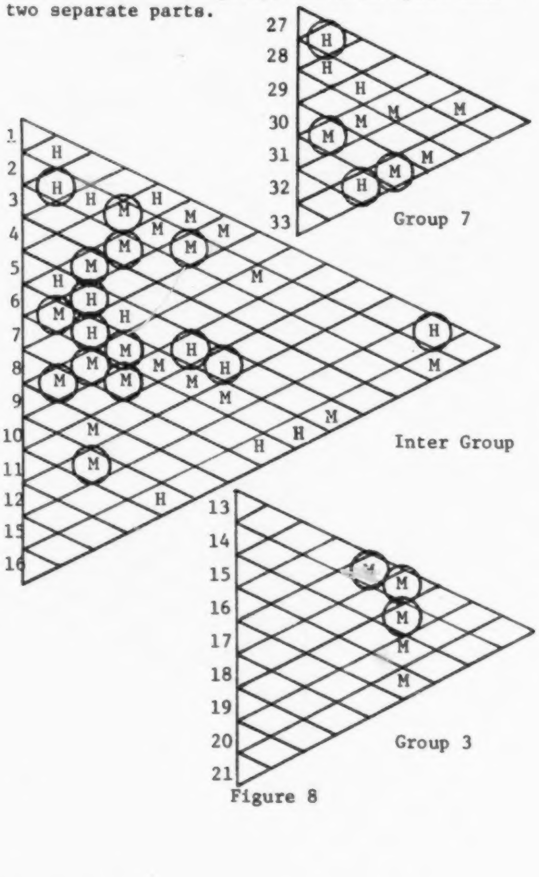


Figure 8

Other interaction weights were experimented with, but none seemed to yield better results than those given in the above examples. The algorithm is extremely sensitive to the values in the interaction and fixed cost matrices so a variety of solutions can be obtained by changing the weighting factors.

The generated layouts can only be evaluated in terms of how well they satisfy the specified interactions. Based solely on this criteria, we can compare the computer generated layouts to the solution arrived at independently by the architects using conventional methods. A simplified block diagram of their final layout with matrices showing the interactions satisfied is given in Figure 9.

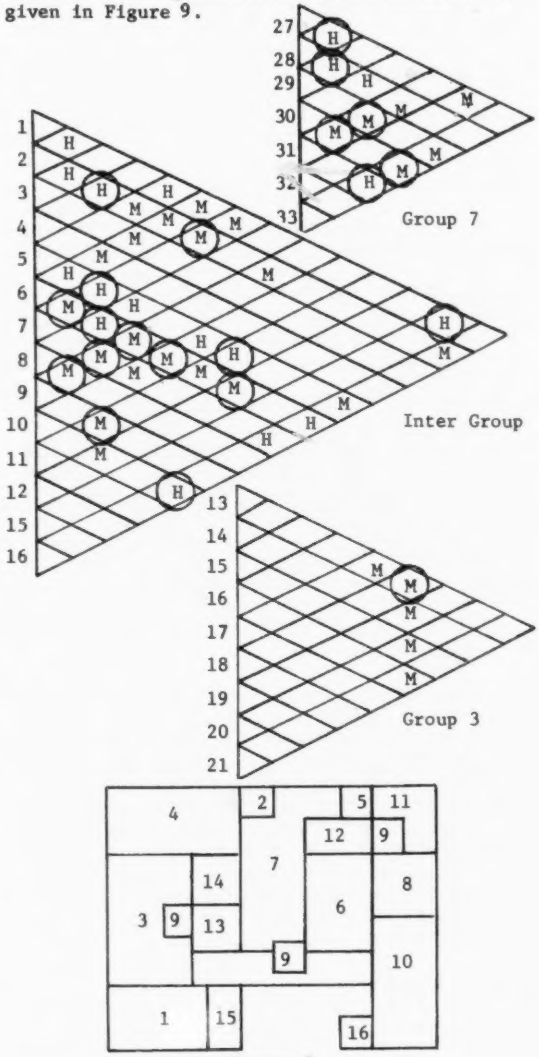


Figure 9

Trust Investment Problem

Figure 10 shows a plan of another type of office layout produced by the program. It is of the Trust Investments Department of a large firm. Forty employees were to be located within the space according to specified adjacency requirements. These requirements were translated into an interaction matrix for the enumeration algorithm. A value of ten was entered if two employees were to be placed in adjacent locations, and a value of zero entered if not. No preassignments or fixed costs were required.

The interaction matrix turned out to be very sparsely populated. Figure 11 gives a breakdown of the matrix into clusters of interacting elements. These clusters are non-overlapping (i.e., no interactions exist between clusters). Due to the sparseness of the matrix, the generated layout was able to meet most of the adjacency requirements.

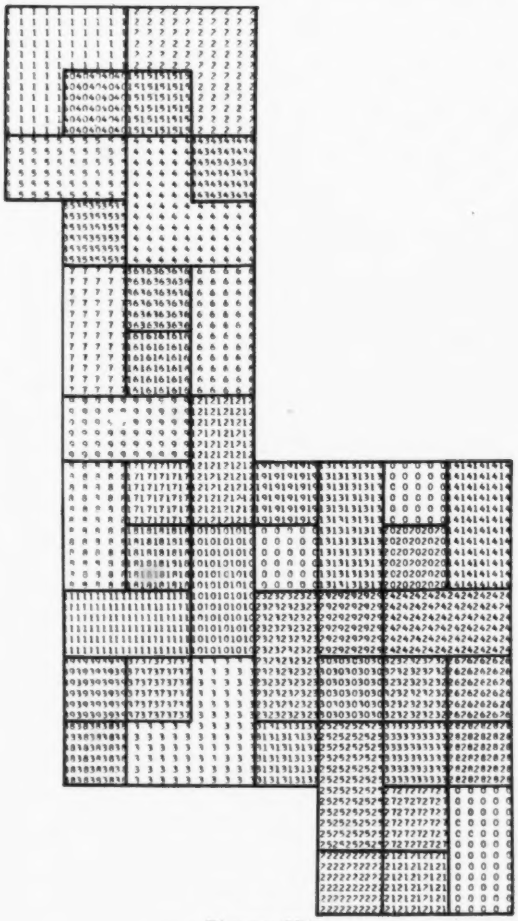


Figure 10A

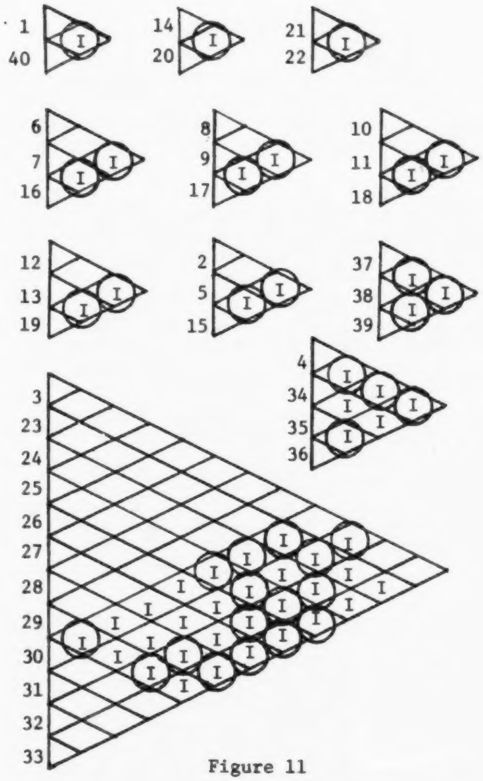


Figure 11

```
THE FOLLOWING  40 ELEMENTS ARE TO BE LOCATED ON THE LAYOUT
NUMBER          NAME                 SQ. FEET  # MODULES  1ST MODULE

   1     VICE PRESIDENT               225.0        3          1
   2     TRUST OFFICER-PORTFOLIO      225.0        3          3
   3     TRUXT OFFICER-RESEARCH       225.0        3          6
   4     TRUST OFFICER-TRADING        225.0        3          9
   5     PORTFOLIO MANAGER            150.0        2         12
   6     PORTFOLIO MANAGER            150.0        2         14
   7     PORTFOLIO MANAGER            150.0        2         16
   8     PORTFOLIO MANAGER            150.0        2         18
   9     PORTFOLIO MANAGER            150.0        2         20
  10     PORTFOLIO MANAGER            150.0        2         22
  11     PORTFOLIO MANAGER            150.0        2         24
  12     PORTFOLIO MANAGER            150.0        2         26
  13     PORTFOLIO MANAGER            150.0        2         28
  14     PORTFOLIO MANAGER            150.0        2         30
  15     SECRETARY                     70.0        1         32
  16     SECRETARY                     70.0        1         33
  17     SECRETARY                     70.0        1         34
  18     SECRETARY                     70.0        1         35
  19     SECRETARY                     70.0        1         36
  20     SECRETARY                     70.0        1         37
  21     MINUTES CLERK                 80.0        1         38
  22     MINUTES CLERK                 80.0        1         39
  23     SECURITY ANALYST-SR.         150.0        2         40
  24     SECURITY ANALYST-SR.         150.0        2         42
  25     SECURITY ANALYST-SR.         150.0        2         44
  26     SECURITY ANALYST-JR.         110.0        1         46
  27     SECURITY ANALYST-JR.         110.0        1         47
  28     SECURITY ANALYST-JR.         110.0        1         48
  29     SECURITY ANALYST-JR.         110.0        1         49
  30     STATISTICIAN                  70.0        1         50
  31     SECRETARY/STAT.               70.0        1         51
  32     SECRETARY                     70.0        1         52
  33     SECRETARY/FILE CLERK          70.0        1         53
  34     TRADER                       110.0        1         54
  35     TRADER                       110.0        1         55
  36     TRADER                       110.0        1         56
  37     COMMON FUND CLERK             80.0        1         57
  38     COMMON FUND CLERK             80.0        1         58
  39     COMMON FUND CLERK             80.0        1         59
  40     ADMINISTRATIVE SEC'Y.         70.0        1         60
THE QUADRATIC ASSIGNMENT PROBLEM IS TO ASSIGN  61 ELEMENTS TO  65 LOCATIONS
MODULE SIZE IS   75.00 SQ. FT.
```

Figure 10B

Interactive Possibilities

Interactive computer graphic systems for problem solving are currently creating a great deal of interest. Interactive graphic programs allow the problem solver to develop plans, designs, or solutions, and obtain an immediate evaluation of the consequences of a particular alternative.

The floor play layout problem is ideal for the application of interactive graphics. Using a cathode ray tube, an outline of the floor plan can be displayed and elements to be located on the plan can be defined. With a graphic input device such as a RAND tablet, the designer can move elements about on the plan searching for a good solution on a trial and error basis.

This type of system could be extremely useful when combined with an algorithm such as the implicit enumeration scheme. Although a good solution is produced using the enumerative algorithm, it can usually be improved by some hand adjustments. Making hand adjustments non-interactively is extremely time consuming, and it is difficult to visualize the results.

The results of the algorithm can be used as a good basic configuration on which to experiment interactively, or the interactive capabilities can be incorporated into the assignment algorithm itself. This could be implemented by letting the user experiment with some possible assignments at each step of the enumerative procedure, rather than the algorithm inspecting all possible assignments. The system would calculate the expected values of the objective function corresponding to a particular assignment, providing the user an indication of how well he is doing. In this manner, the user would try a number of combinations at each step, selecting the one which appears most likely to lead to an optimal solution. Here, human intuition would be used to reduce the number of alternatives to be examined by the program.

These methods could be combined into one program in which the user has the option of asking for a program generated solution or can attempt the assignments himself with the aid of the algorithm. In either case, interactive capabilities could improve the solution procedure.

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A POLYOMINO ASSEMBLY PROCEDURE FOR ARCHITECTURAL FLOOR PLANNING

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Abstract

The problem of generating preliminary, rough ideas for floor-plan layouts is considered. It is suggested that preliminary layout diagrams of useful quality may be produced by application of some very simple heuristic form-generation rules, and that computational procedures which can produce a wide range of such diagrams very quickly, and cheaply are thus feasible. A recently implemented program which follows this principle is discussed, and the properties of the results which it produces analyzed. The program, DOMINO, was developed for Welton Becket and Associates, Architects, Los Angeles, and is now in use in their office on commercial and hospital building design projects.

Objectives of the Project: Development of a Procedure for Gaining Insight into Scale, Form, and Relations between the Parts of a Floor Plan

The series of sketches of floor plan layouts shown in Figure 1 (over page) illustrates a characteristic evolution from simple, crude, early diagrams to a precisely dimensioned, highly detailed, carefully worked out final scheme. At the very earliest stages of this process, an architect will usually seek insights into the problem by generating quite an extensive series of grossly approximate diagrams to explore questions of scale, form, and relationship between the parts. This paper discusses the principles, development, and operation of a computer program, DOMINO, intended to assist in the designer's explorations by making the production of such diagrams quicker, cheaper, and easier. It was conceived, developed, and implemented in June 1971 for the Los Angeles-based architectural firm of Welton Becket and Associates, and is now in use in their offices.

The properties required of such a program, if it is expected to be practically useful were identified as follows:

(1) It should be capable of producing intelligible, reasonable, useful results in response to the very simple, imprecise, and incomplete data likely to be available at that early stage in the design process.

(2) It should be capable of producing a wide range of useful alternative diagrams in response to any given set of input data. The object is not to automatically produce some allegedly "optimum" solution, but to assist in a process of exploration.

(3) Production of diagrams should be as quick and as cheap as possible. In particular, if one wishes to deal with realistically sized problems, it must be ensured that computation time increases not much more than linearly with the number of spatial elements to be manipulated.

It is important to distinguish a program intended for this type of use from programs developed for application at later stages in the design process, where one can expect objectives and constraints to be specified much more completely and precisely, to the point where it may be reasonable to expend quite a lot of computational effort in searching for a uniquely preferred solution, or at least a small set of superior solutions (1). At the earliest stages of the process, our aim is more modest. Rather than search for a solution, we seek to understand the problem.

Representation Scheme

In order to develop a computational procedure for generating floor plan layout diagrams, it is first necessary to define some appropriate method of representing these diagrams in a computer. One such method is illustrated in figure 2. A plane is divided into squares, and each of the squares is assigned a pair of numerical coordinates. The diagram which we wish to represent is then mapped onto this grid, by superimposition, as shown. The two-dimensional array of integers which results represents the diagram to any desired degree of accuracy. This method of representation has certain limitations (2), but since it is simple conceptually, simple to program, and adequate for our purposes, it was adopted.

Diagram Generation Strategy

Perhaps the best starting point for discussion of the diagram generating strategy which was developed in the observation that floor plan layout diagrams, when mapped into two-dimensional arrays, are polyominoes. Polyominoes are shapes made by connecting equal-sized squares, each joined together with at least one other square

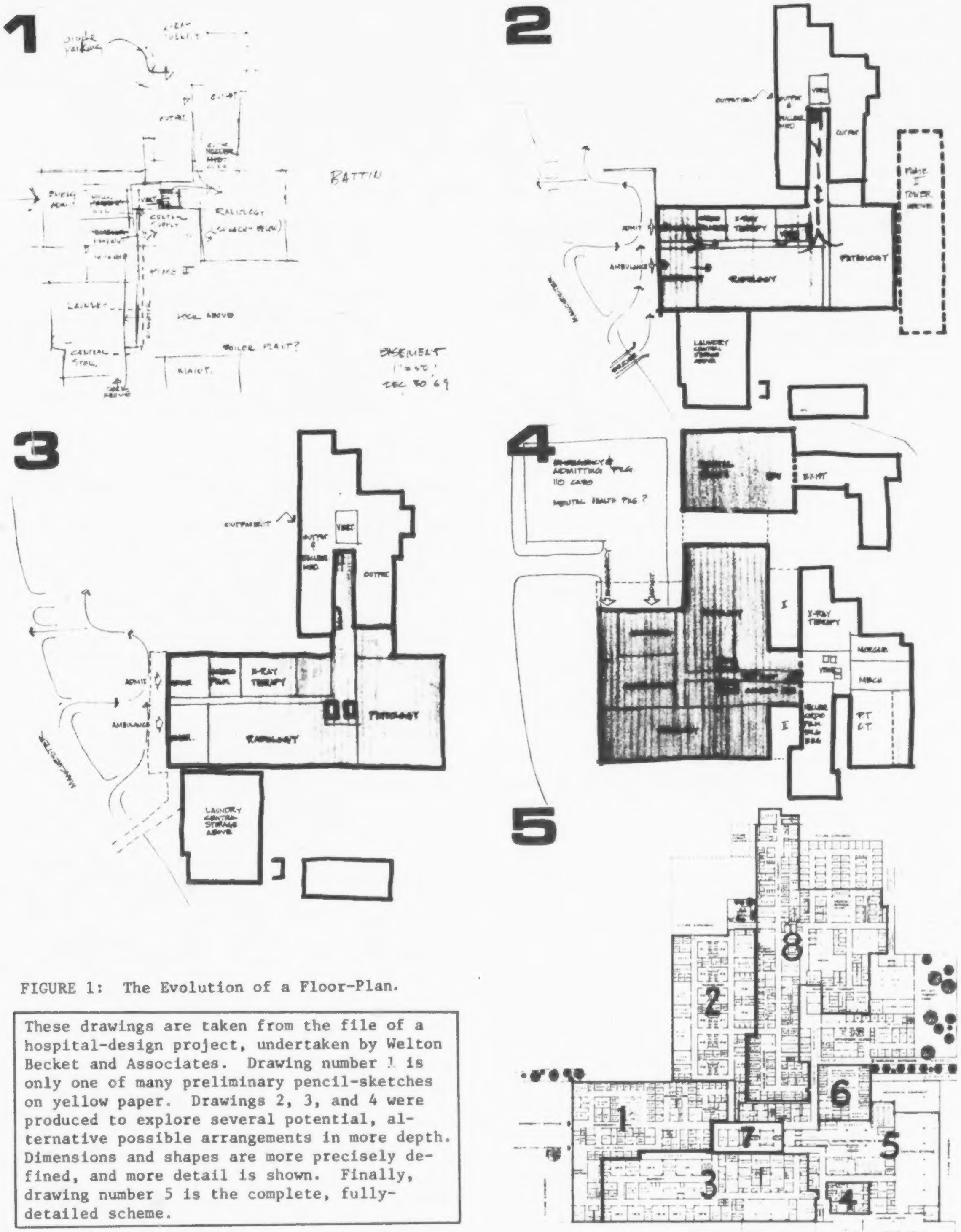
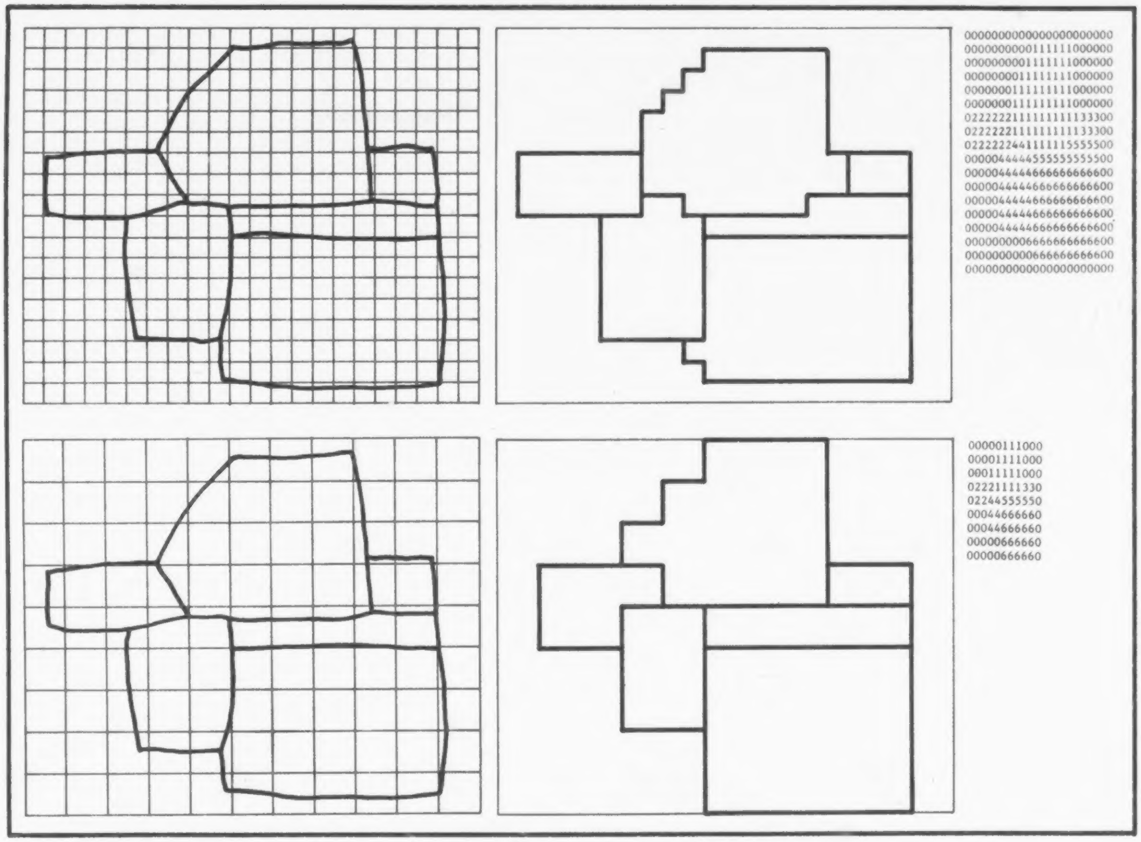

1
2
3
4
5
BATTIN
RADIOLOGY
LAUNDRY
BOILER PLANT?
MAINT.
BASEMENT
DEC 30 '69
OUTPATIENT
X-RAY THERAPY
PATHOLOGY
ADMIT
AMBULANCE
PHASE I TOWER ABOVE
LAUNDRY CENTRAL STORAGE ABOVE
EMERGENCY & ADMITTING PKG 110 CARS
MENTAL HEALTH PKG ?
MORGUE
MECH
PT OT
8
2
6
1
7
5
3
4

FIGURE 1: The Evolution of a Floor-Plan.

These drawings are taken from the file of a hospital-design project, undertaken by Welton Becket and Associates. Drawing number 1 is only one of many preliminary pencil-sketches on yellow paper. Drawings 2, 3, and 4 were produced to explore several potential, alternative possible arrangements in more depth. Dimensions and shapes are more precisely defined, and more detail is shown. Finally, drawing number 5 is the complete, fully-detailed scheme.



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0000000000111111000000
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0000000111111111000000
0000000111111111000000
0222222111111111133300
0222222111111111133300
0222222441111115555500
0000044445555555555500
0000044444666666666600
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0000000006666666666600
0000000000000000000000
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00000111000
00001111000
00011111000
02221111330
02244555550
00044666660
00044666660
00000666660
00000666660
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FIGURE 2: Representations of a complex shape by an array of integers.

along an edge (3). Figure 3 shows some examples: all the possible polyomino shapes for four or fewer squares (excluding reflections and rotations).

It is possible to "grow" polyominoes of any area by starting with a single square and adding squares, one at a time, in such a way that the new square has at least one side in contact with a side of a square already present (4). The life histories of all possible polyominoes may then, in principle, be displayed by means of a single tree diagram, a portion of which is illustrated in figure 4.

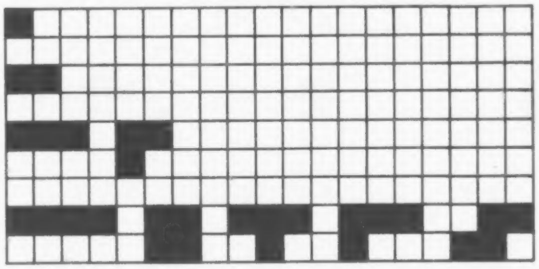

FIGURE 3: Examples of polyominoes.

More complex patterns may be generated by dividing the squares into different classes, for example, by assigning them different colors. Figure 5 illustrates the morphogenisis of patterns in which the squares may be either black or white.

It becomes evident from these diagrams, that it is possible to grow polyomino patterns possessing any particular desired properties, provided that the pattern sought does in fact exist, and that we possess some means of determining which alternative branch to take at any given point. Where there is no distinction between squares, we simply need decision rules or procedures for choosing between alternative possible positions for placement of the next square. Where squares are divided into different classes, we must add a second type of rule or procedure, for deciding the class of the next square to be placed.

The floor plan generation program, DOMINO, consists essentially of a set of procedures for answering the questions "What type of square should be placed next?", and "In which of the possible growth positions should it be located?" in such a way that polyomino patterns possessing certain desirable properties are generated.

The general properties are that:

(1) Each department is of some specified area;

(2) Certain specified proximity relationships between departments are satisfied.

(3) Where conflict between proximity requirements exists, those which are defined as more important are satisfied rather than those regarded as less important;

(4) Departments are of reasonably simple shape and acceptable proportions.

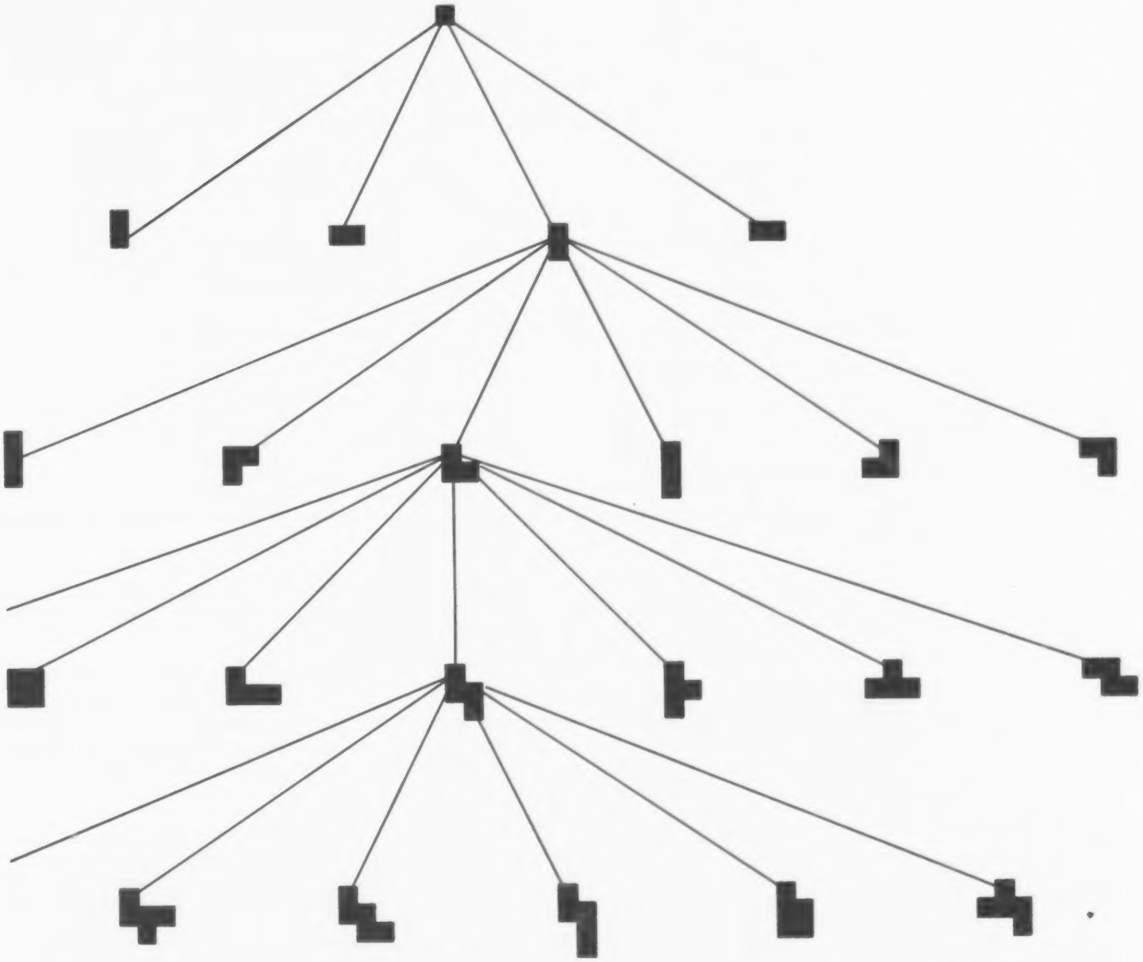

FIGURE 4: Morphogenesis of polyominoes.

The specific required departmental areas, proximity relationships, and the rank order of importance of relationships are defined by the user, and input as data. A typical set of input data is illustrated in figure 6.

The procedure which was developed to answer the question, "What type of square should be placed next?" is shown in figure 7. Essentially, the method is to first create from the input data a rank-ordered list of all pairs of departments between which an interaction has been defined.

When a department has been placed, this list is scanned down to a certain rank to discover any other department to which it is closely linked. If such a department is found, that department is placed next. If not, a link to the department which was placed immediately previously is sought, and so on back to the first department to be placed. If no strong link is found to any placed department by this process, the depth of scan is increased, and the search repeated. This cycle continues until an appropriately linked department is found. All the squares of that de-

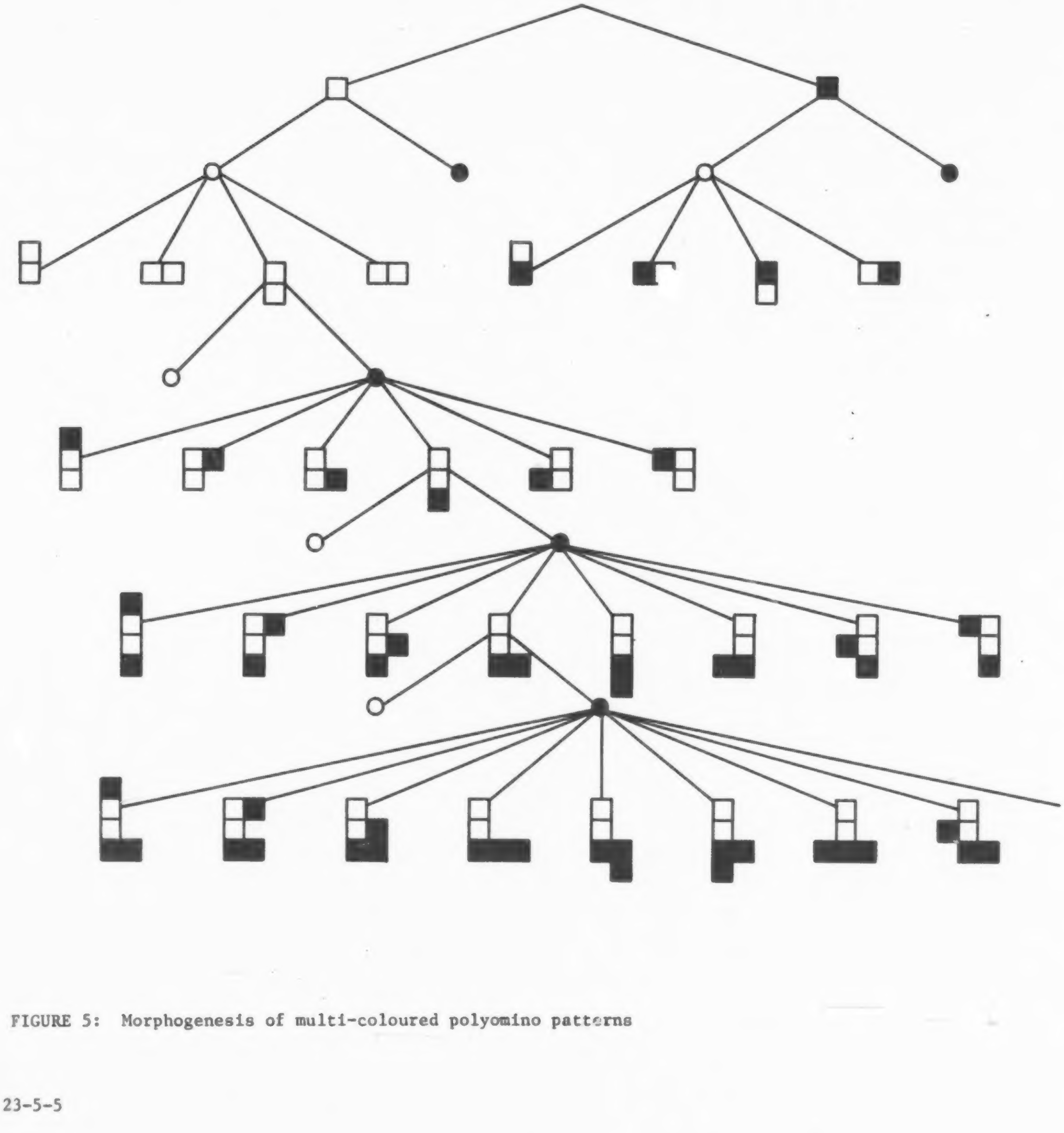

FIGURE 5: Morphogenesis of multi-coloured polyomino patterns

partment are next added to the pattern, on the outer perimeter of the department with which the link was discovered, then the next department to be added is sought in the same way.

It does not appear to make very much difference to the quality of the results whichever department is placed first. Thus the first department is selected arbitrarily.

The question "Where should the next square be added?" is answered by first establishing a list of possible polyomino growth positions around the perimeter of the department to which it is to be attached. The list is then subjected to a sequence of tests, in pre-determined order. If a position passes the test, it remains on the list, and if not, it is eliminated. As many tests as are necessary are executed, until the list is reduced to one member.

Many different possible sequences of tests plausibly suggest themselves. After some experimentation with different selection rules, applied in various different sequences, the following were chosen:

(1) Neighbour counting test:

Each potential growth position on the list has eight "neighbours," A, B, C, D, E, F, G, H, as shown in figure 8. Of these neighbours, B, D, E, and G may be termed "face neighbours" and A, C, F, and H "diagonal neighnours." These neighbours may be unoccupied, occupied by portions

Department	No.	Area (sq. ft.)	Required Adjacencies (Rank-ordered left to right)									
			1	2	3	4	5	6	7	8	9	10
Executive Offices	1	3625	2	3	16	24	15	8	9			
Administration	2	5435	1	3	8	16	24	6	5			
Finance Management	3	1600	4	2	1	8	11	19	10	13		
Accounting	4	8960	3	2	1	8	11	19	10	13		
Public Relations	5	1000	1	8	9	24	16	2	26	11		
Statistical Research	6	10070	1	16	24	19	8	25	22	14		
Management Training	7	4605	19	2								
Conference Rooms	8	1805	1	2	17	25	26	19	18			
Food Service	9	5700	1	5	18	26	16	24	2			
Mail Room	10	1000	17	25	3	4	19	22	26			
Copy Center	11	400	25	17	3	4	20	22	19			
Communications Center	12	400	20	17	19	25	6	4	10			
Nurse	13	400	26	25	20	19	6	2	1	16		
Bldg.Service Security	14	27000	19	14	8	25	12	9	8	6		
Entry/Reception/Visitor	15	36000	1	24	19	6	23	25	26	16		
Division Management	16	2405	6	17	18	1	2	5	8	14		
Project Control	17	21635	18	8	10	11	12	6	2			
Product Management	18	3805	17	16	2	6	9	8	19			
Client Service Group	19	15520	16	22	23	8	6	10	11			
New Products	20	2910	19	18	17	6	12	11	5			
Special Research	21	1770	23	6	2	16	17	18	11			
Test Control	22	830	6	19	17	18	2	11	10			
Consumer Research	23	2000	21	19	6	18	8	3	5			
Division Management	24	1040	6	15	2	5	3	4	25			
Client Service Group	25	4505	24	8	11	10	12	19	4			
Sales	26	1000	11	8	2	15	13	9	15			

FIGURE 6: Typical Input Data.

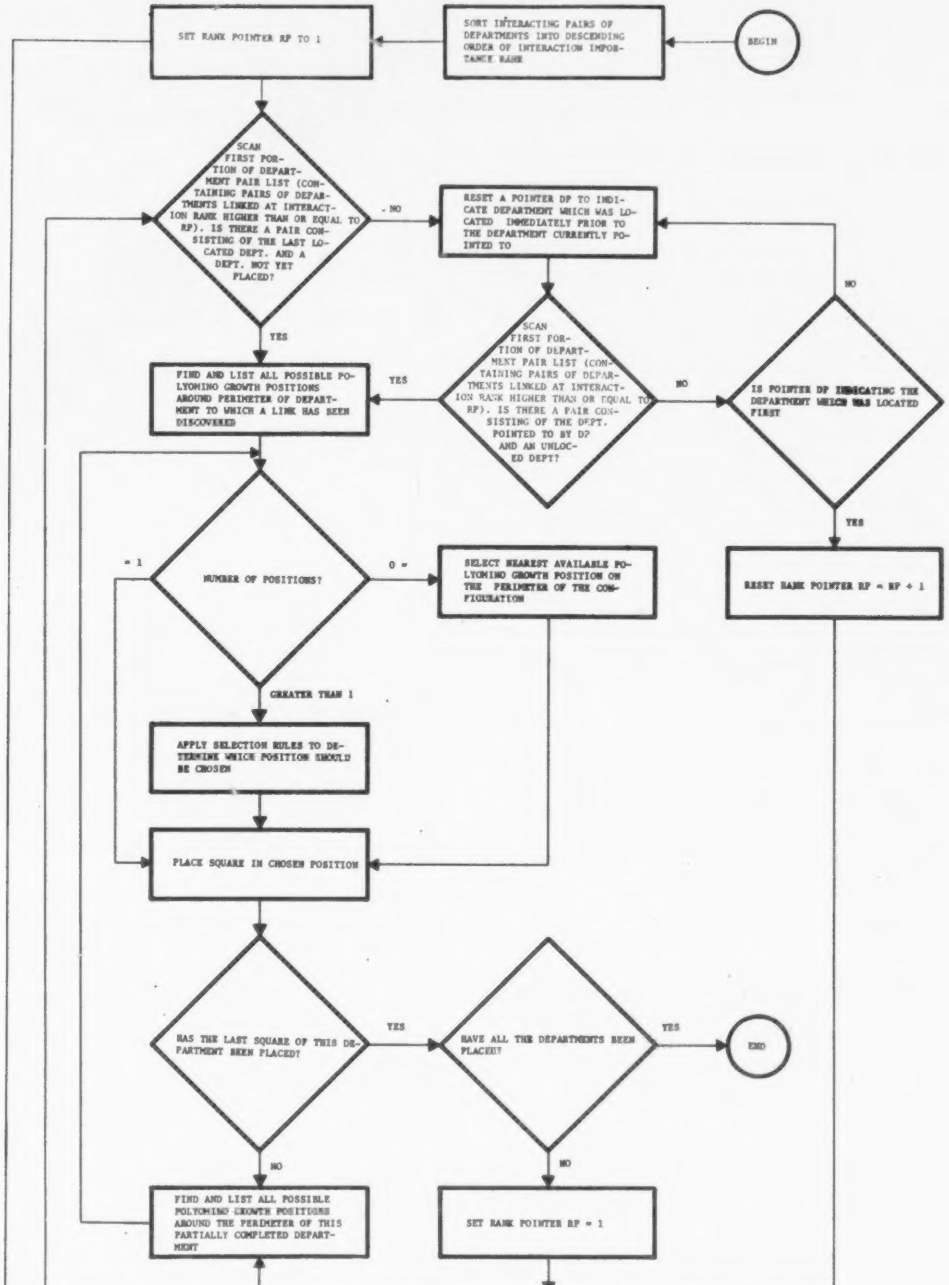
BEGIN
SORT INTERACTING PAIRS OF DEPARTMENTS INTO DESCENDING ORDER OF INTERACTION IMPORTANCE RANK
SET RANK POINTER RP TO 1
SCAN FIRST PORTION OF DEPARTMENT PAIR LIST (CONTAINING PAIRS OF DEPARTMENTS LINKED AT INTERACTION RANK HIGHER THAN OR EQUAL TO RP). IS THERE A PAIR CONSISTING OF THE LAST LOCATED DEPT. AND A DEPT. NOT YET PLACED?
NO
RESET A POINTER DP TO INDICATE DEPARTMENT WHICH WAS LOCATED IMMEDIATELY PRIOR TO THE DEPARTMENT CURRENTLY POINTED TO
NO
YES
FIND AND LIST ALL POSSIBLE POLYOMINO GROWTH POSITIONS AROUND PERIMETER OF DEPARTMENT TO WHICH A LINK HAS BEEN DISCOVERED
YES
SCAN FIRST FORTION OF DEPARTMENT PAIR LIST (CONTAINING PAIRS OF DEPARTMENTS LINKED AT INTERACTION RANK HIGHER THAN OR EQUAL TO RP). IS THERE A PAIR CONSISTING OF THE DEPT. POINTED TO BY D? AND AN UNLOCED DEPT?
NO
IS POINTER DP INDICATING THE DEPARTMENT WHICH WAS LOCATED FIRST
YES
= 1
NUMBER OF POSITIONS?
0 =
SELECT NEAREST AVAILABLE POLYOMINO GROWTH POSITION ON THE PERIMETER OF THE CONFIGURATION
RESET RANK POINTER RP = RP + 1
GREATER THAN 1
APPLY SELECTION RULES TO DETERMINE WHICH POSITION SHOULD BE CHOSEN
PLACE SQUARE IN CHOSEN POSITION
HAS THE LAST SQUARE OF THIS DEPARTMENT BEEN PLACED?
YES
HAVE ALL THE DEPARTMENTS BEEN PLACED?
YES
END
NO
NO
FIND AND LIST ALL POSSIBLE POLYOMINO GROWTH POSITIONS AROUND THE PERIMETER OF THIS PARTIALLY COMPLETED DEPARTMENT
SET RANK POINTER RP = 1

FIGURE 7: Simplified flow diagram of DOMINO.

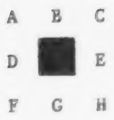

FIGURE 8: Neighbours of a cell

of other departments, or occupied by previously-placed squares of the department currently being located. In executing the neighbour counting procedure, the first step is to determine how many neighbours of each potential position are occupied by previously-placed squares of the current department. If one position has more such neighbours than any other, it is selected. If two or more are tied at the highest value, a second count is made to distinguish between them,, but this time, only "face neighbours" are considered. If a tie still remains, neighbours occupied by portions of other departments to which the current department is linked at rank 1 are counted, then the "face neighbours" at this rank, then rank 2 "neighbours" and "face neighbours," and so on as far as rank 8.

(2) Centroid distance test:

Where two or more posiitons cannot be separated by the neighbour counting tests, their distances to the centroid of the department to which they are attached are calculated, and the position closest to the centroid selected.

(3) Freedom to grow test:

In the event that a tie still exists, the numbers of unoccupied neighbours of each remaining position are determined, and the position with most empty squares around it selected.

(4) Arbitrary tie-breaking:

Finally, if after all the tests, a tie still remains, it is arbitrarily broken by selecting the first member of the list of remaining potential positions.

The easiest way to understand the operation and effect of this set of rules is to trace the growth patterns which it generates. The simplest situation to consider is the free growth of a single department, unconstrained by the presence of other departments. In this situation, we require only that it takes on reasonable proportions. Figure 9 is a portion of a diagram which shows the rectangular envelopes of all possible polyominoes. The rules constrain growth in such a way that all successive growth stages are squares, or close approximates to squares, fitting within those envelopes immediately adjacent to the diagonal. A common form of relationship between departments is a "chain," where department A is linked to B, B to C, C to D, and so on. In such circumstances, the type of form shown at the left in figure 10 will normally result. Other common relationships are "stars" (A is related to B, C, D, and E) and "triangles" (A is related to B, B to C, and C to A). Patterns which may grow in response to these situations are also shown in figure 10. Figure 11 illustrates the successive stages of growth of a typical pattern of realistic complexity, according to the relationships specified by the input data shown earlier (figure 6).

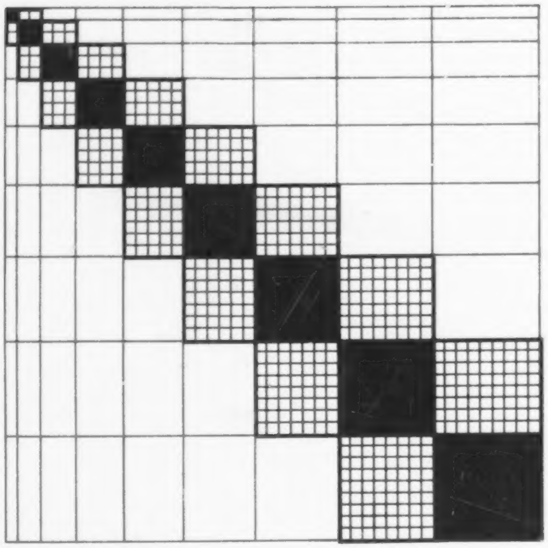

FIGURE 9: Pattern of free growth

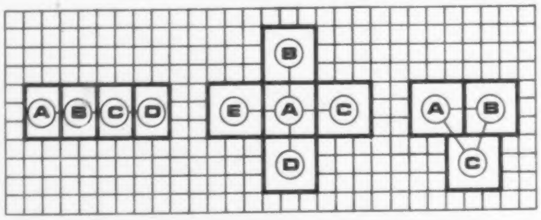

FIGURE 10: Growth in response to interactions

The growth and form of these patterns for a given set of conditions, though complex and unpredictable, is a completely determinate process, leading to a unique result. However, by varying the conditions under which the growth takes place, it is

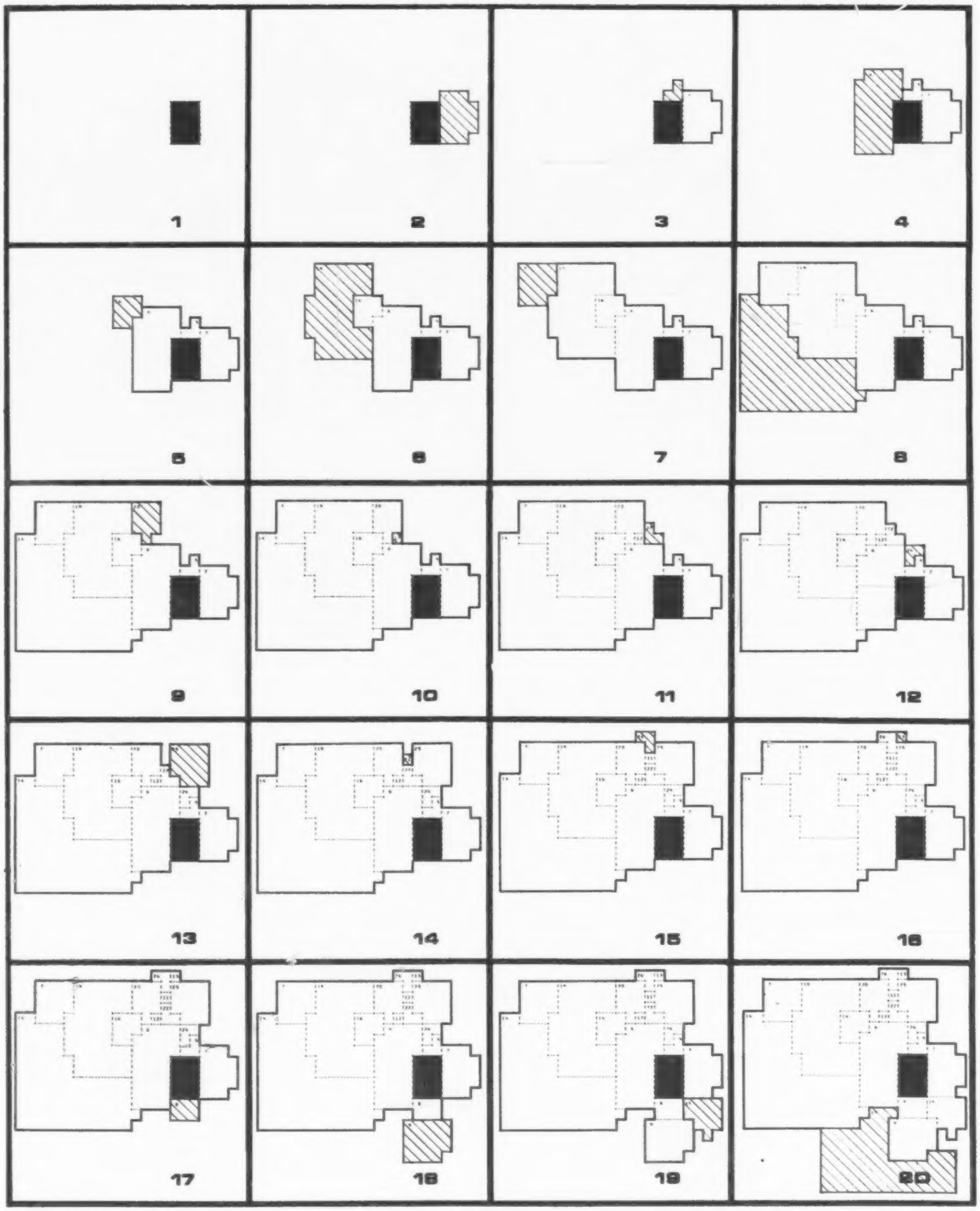
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FIGURE 11: Stages of development of a pattern.

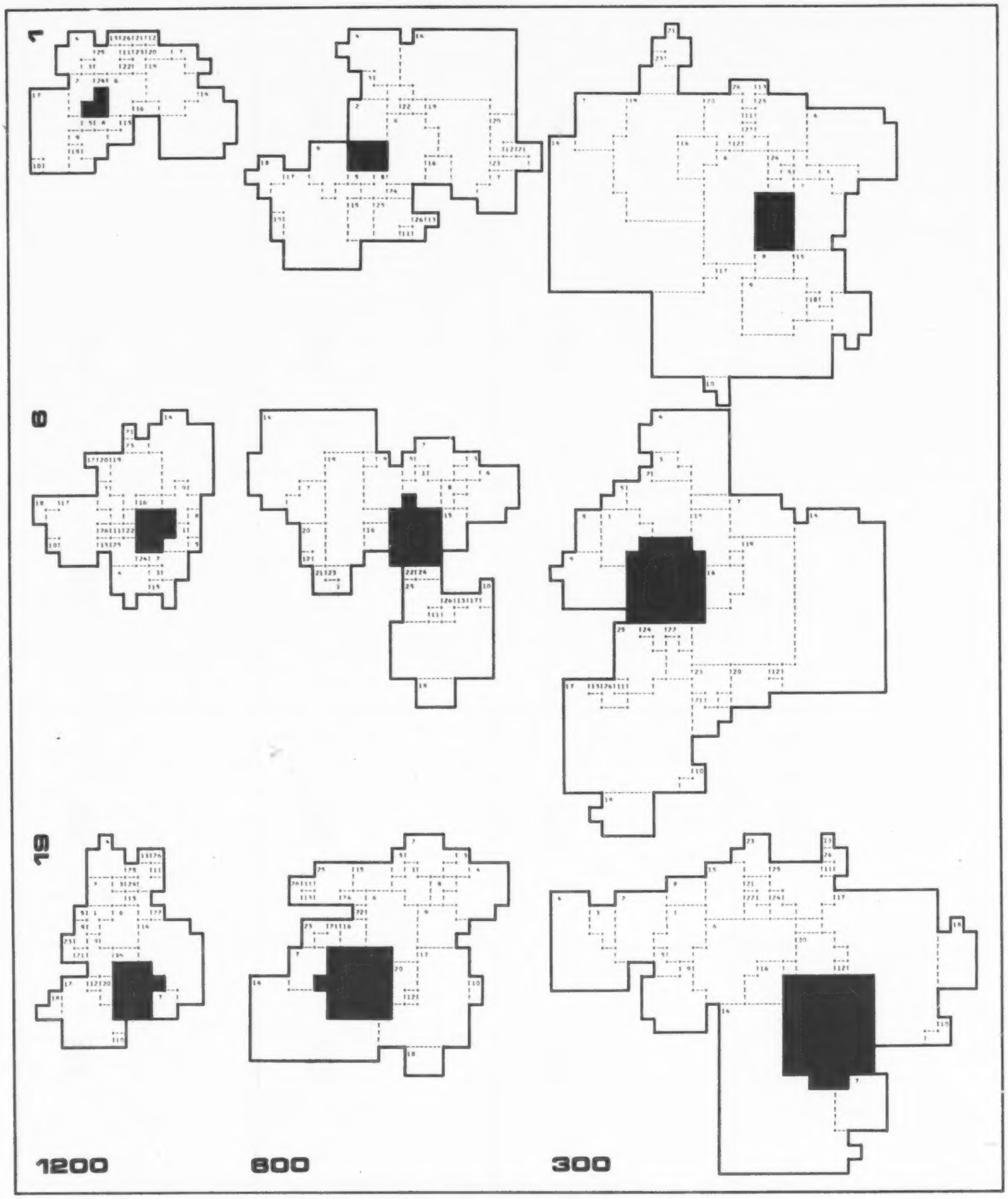

FIGURE 12: Variations of patterns produced in response to the same data. Patterns in row 1 all commenced with placement of Department No. 1, those in row 2 with Department 6, and those in row 3 with 19. The module-size in column 1 is 1200 sq. ft., 600 in 2, and 300 in 3.

RESULT NUMBER	MODULE SIZE (sq.ft.)	STARTING DEPT.	SATISFACTION OF ADJACENCY REQUIREMENTS										NO. OF MODULES PLACED	CPU TIME REQUIRED (seconds) on 360/91
		RANK	1	2	3	4	5	6	7	8	9	10		
		NUMBER SPECIFIED	26	26	25	25	25	25	25	8	0	0		
			NUMBER SATISFIED											
1.	200	1. Executive Offices	24	10	6	3	4	7	3	0	0	0	616	2.72
2.	200	19. Client Service	26	6	7	2	6	4	6	3	0	0	616	2.72
3.	200	6. Statistical Research	26	8	5	5	6	5	4	0	0	0	616	2.72
4.	200	17. Project Control	25	10	6	3	5	4	5	2	0	0	616	2.72
5.	200	25. Client Service	25	9	6	2	5	3	7	0	0	0	616	2.72
6.	200	16. Division Management	26	11	6	3	6	6	4	2	0	0	616	2.72
7.	200	20. New Products	25	8	7	3	7	4	5	2	0	0	616	2.72
8.	200	24. Division Management (2)	26	8	7	3	3	6	5	1	0	0	616	2.72
9.	200	11. Copy Center	26	8	7	0	5	3	5	0	0	0	616	2.72
10.	200	26. Sales	24	9	6	3	4	5	6	0	0	0	616	2.72
11.	400	1. Executive Offices	24	6	7	2	5	5	5	0	0	0	308	1.22
12.	400	19. Client Service	26	9	7	3	4	3	4	3	0	0	308	1.22
13.	400	6. Statistical Research	25	6	7	2	5	3	4	0	0	0	308	1.22
14.	400	17. Project Control	24	8	5	3	4	3	5	2	0	0	308	1.22
15.	400	25. Client Service	25	10	6	3	6	4	5	0	0	0	308	1.22
16.	400	16. Division Management	25	8	7	5	5	5	4	1	0	0	308	1.22
17.	400	20. New Products	26	9	7	4	3	3	4	3	0	0	308	1.22
18.	400	24. Division Management (2)	25	7	7	2	4	6	4	0	0	0	308	1.22
19.	400	11. Copy Center	25	9	7	2	6	3	4	0	0	0	308	1.22
20.	400	26. Sales	25	9	6	3	3	3	3	2	0	0	308	1.22
21.	800	1. Executive Offices	26	8	6	2	4	4	4	0	0	0	159	0.67
22.	800	19. Client Service	26	9	5	2	4	2	3	1	0	0	159	0.67
23.	800	6. Statistical Research	25	9	6	2	5	2	5	1	0	0	159	0.67
24.	800	17. Project Control	24	8	6	2	3	5	5	1	0	0	159	0.67
25.	800	25. Client Service	25	8	6	1	5	3	5	1	0	0	159	0.67
26.	800	16. Division Management	25	8	6	2	5	4	4	0	0	0	159	0.67
27.	800	20. New Products	25	8	5	2	3	4	4	1	0	0	159	0.67
28.	800	24. Division Management (2)	26	10	7	4	5	3	3	0	0	0	159	0.67
29.	800	11. Copy Center	25	8	6	2	6	2	4	3	0	0	159	0.67
30.	800	26. Sales	25	8	6	1	5	2	4	4	0	0	159	0.67
		AVERAGE PERCENTAGE OF ADJACENCY REQUIREMENTS SATISFIED:	98	32	38	15	28	23	27	13	-	-		TOTAL CPU TIME: 46.11

TOTAL COST AT CURRENT UCLA RATES:$12.50

FIGURE 13: Evaluation of patterns produced in response to the data shown in figure 6.

possible to systematically generate a wide range of alternative results in response to a given set of data. The conditions which may be varied are:

(1) The department to which the first square placed belongs.

(2) The area of the square. Since each department, and the pattern as a whole, have a fixed area, decreasing the area of the square modules results in an increase in their numbers.

Typical results of making such variations are shown in figure 12. Altering the department of the starting square radically rearranges the whole result. Increasing the number of squares usually leaves the general arrangement largely unaltered, but allows freer and more complex departmental shapes. In neither case is the number of required relationships which are satisfied greatly altered.

An alternative way of achieving such a range of different results would be to introduce a random element into the growth rules employed. However, it was felt that systematic exploration of possibilities was to be preferred.

Evaluation of Results

The objective in development of this type of program is not to produce the best possible results; it is to achieve an appropriate balance between cost and quality of results relative to the particular design situation for which its use is intended. A summary of the cost and quality of thirty patterns produced from the data illustrated in figure 6 is given in figure 13. Preliminary floor plan layout diagrams are of useful quality when the departments are of approximately correct area, shapes and proportions, are reasonable, and most of the major contiguity requirements are satisfied. Results produced by DOMINO consistently meet these standards. The cost of generating patterns must be low enough for it to be economically feasible to explore a large number of them. DOMINO also meets this criteria successfully; a pattern is produced for a few cents. These results are in striking contrast to most spatial arrangement procedures (particularly enumerative approaches) in which the increase is notoriously exponential (5).

A different trade-off between cost and quality of results than the one which was chosen could be achieved by alteration of the decision rules which control where a particular square should be added to the pattern. Those used at present require very little computation because they are very "local" in character. In other words, only the most immediate consequences of locating a given square in a given position are assessed, and no attempt is made to evaluate long-term effects. This is analogous to playing chess thinking only one move ahead. More "global" rules, looking further ahead, and presumably producing better quality results as a consequence, could obviously be devised. But, in general, the more local the decision rule, the less computation (and hence cost) it will require. Furthermore, computation time required for generation of a polyomino pattern seems normally to be roughly proportional to some exponent of the total number of squares to be located in the pattern. Using very local rules, this exponent can often be reduced almost to 1, but with more global rules it inevitably becomes higher, and this imposes very definite bounds on the size of patterns which we can attempt to generate. Perhaps a scheme which could utilize both local and global rules, at different stages in the pattern generation process would achieve the best balance between cost and quality. Further experiments with the program will explore this idea.

Directions for Further Development

The initial developmental version of this program was implemented in batch mode, giving line-printer output. However it is clear that the potential of such an aid to exploration of alternatives can only be fully realized if it is available in a very flexible interactive graphic mode. Consequently, a second version is being implemented on a PDP-10 computer and Computek storage tube terminal at UCLA. Work is proceeding on development of an appropriate interactive interface with the user, and in further exploration of the properties of different sets of growth rules.

Notes

(1) See for example papers by Fullenwider, and Liggett, this volume.

(2) March, Lionel and Steadman, Philip, Irregular Polygons and Convexity, Chapter 7 of The Geometry of the Environment, RIBA Publications, London, 1971.

Eastman, Charles, Representations for Space Planning, in Communications of the ACM, Vol. 13, No. 4, April, 1970.

Wells, Mark B., Geometric Configurations, Chapter 3.6 of Elements of Combinatorial Programming, Pergamon, 1970.

(3) Golomb, Solomon W., Polyominoes, Scribners, 1965.

(4) Read, R.C., Contributions to the Cell Growth Problem, in Canadian Journal of Mathematics Vol. 14, No. 1, pp. 1 - 20.

See also Frew, Ragade, and Roe, this volume.

(5) Nugent, C.E., Vollman, T.E. and Ruml, An Experimental Comparison of Techniques for Assignment of Facilities to Locations, in Operations Research, Vol. 16 pps. 150 - 173 (January - February 1968).

A COMPUTER MODEL OF THE DESIGN PROCESS THAT USES A CONCEPT OF AN APARTMENT FLOORPLAN TO SOLVE LAYOUT PROBLEMS

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Abstract

This paper describes how conjectures about human design intelligence might be used in an attempt to program that intelligence for 'computer assisted designing'. The paper also examines to what extent programming can serve as a tool to make hypotheses about human designing explicit and more concise, and how programming helps to assess the productivity and plausibility of any proposed theory of design. By focusing on an area of artificial design that has received a good deal of attention (floorplan layout), a basis for comparison with other approaches that are not based on behavioural modeling is maintained. A program has been written in Micro-PLANNER. The program has some general knowledge about efficiency apartment floorplans, such that it can solve a few problems that are presented in the form of a problem environment. The validity of behavioural modeling to research in methods of environmental design is discussed. The simulation has not reached the critical point, however, where we expect an explanation of 'creativity' in design.

Motivation

We shall argue that resourceful computer design aids have to know a lot about the objects that they might be asked to design (and ultimately about the world), and that they have to engage in reasoning not unlike the human designer's, such that they can take into account the whole diversity of considerations relevant in designing. These two points distinguish this work from the general programs that have dominated computer assisted designing to date.

This work pursues two related goals. First, we would like to use the computer more creatively in designing. Second, we would like to improve our understanding of the human design process. Consideration of previous work in this area suggests that a better understanding of the human design process might well be the key to our improving of computer aided designing, and that the creation of an artificial designer might be the only way to arrive at some theory of design that is concise and complete within its limited scope, and whose properties are open to performance tests and criticism by comparison with human performance. Thus we find a strong mutual dependence between the two goals of this work. This dependence is the reason for our belief that work of this kind is of importance when trying to understand how designing is done in the mind, and how machines can be programmed to help designing.

The approach has been called "psychological modelling" (1). We have introduced the basic reason for choosing that approach, but there are additional advantages in the design of a program that works in human terms and has a problem solving strategy that aims to be like a human method. Since we are not primarily interested in completely automated design for its own sake, we will certainly want to communicate with the artificial designer to give instructions and ask questions. We want it to understand our human usage, and we want to understand the reasoning of the artificial designer. In this whole question of communication 'psychological modelling' has some favourable implications that do not exist in other computer methods (1).

We do not know of any psychological experiments about designing that would be helpful in this work (2). Although there have been protocols noting the observable behaviour of designers (3), these protocols reveal little, if anything, about the computations that generated the observable output.

On the other hand, there are some very general notions about human problem solving such as hierarchical organization and planning. They are of great importance in designing, but have never been implemented in a computer model that is supposed to design. There are other characteristics of our program's problem solving strategy that seem to be more specific to designing, but which are by no means limited to floorplan layout.

The major source of the problem solving strategy is introspection. This does not imply, however, that the results are strictly personal, because designing is probably not very personal in those basic mechanisms.

It is useful to distinguish two kinds of knowledge of an artificial designer. First, knowledge about the objects it might be asked to design or help design (essentially data). Second, ability to use that knowledge when dealing with design problems (procedures). It can be shown, however, that this is a somewhat arbitrary distinction because data describing a possible world have a procedural analogue in programs to create that world (4). But from a historical point of view, this distinction is enlightening because computer design aids to date were entirely without knowledge about the world. Their general procedures can only use very little data of a particular kind given in an 'explicit' problem statement (5).

Most approaches to computer aided design share the basic assumption that there is a great merit in man-machine interaction in problem solving, as opposed to providing a self contained model of the design process based on some theory of design. This position has been reinforced by the lack of any theory - specifically of design - that is detailed and complete enough to be productive, however small its scope. Certainly, the human designer is by all measures superior to any artificial designer that has been constructed to date. This sounds like an argument in favour of man-machine interaction. But the question really to be raised is: To what extent do present day computer design aids aid in design?

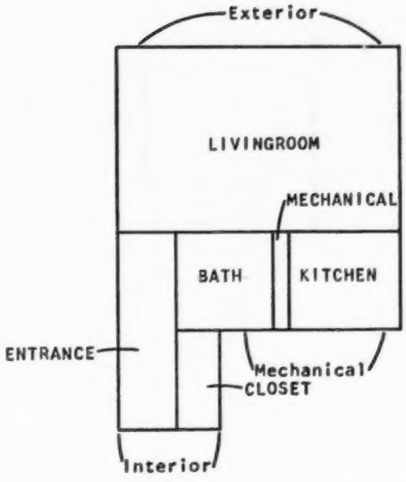
We are attempting to construct an artificial designer, because we want to find out how this could be done, and because we think that only an artificial designer with a high degree of completeness and intellectual independence will be a helpful partner in an interactive problem solving environment.

When attempting to provide knowledge to a computer program in a particular domain, we face several questions. What do we know? What is it we want to provide? What is a suitable expressive domain (6)? To provide architectural concepts of apartment floorplans, we decided to use a form that relies on the description of component elements (objects), their relations, and attributes: rooms; adjacency relations; and shape, area, and dimensions, respectively. By adopting these few local terms we hoped to achieve some generality of the concept, and ease of conception in response to a particular design problem. An architectural concept is intended to define the set of all admissible forms that an 'architectural object' such as an apartment house or an efficiency apartment can take on. An architectural concept is part of the subject knowledge of a designer; it is the exclusive subject knowledge of our artificial designer.

Our concept is a semantic definition in terms of certain design specifications plus associated programs for interpretation of the data. There are other meanings to such a concept which our program does not know. The content of our description has been called "the syntax of architecture" to distinguish it from "the semantics of architecture" (7), but this is a misleading terminology. As opposed to "the syntax of architecture" "the semantics are measured with calipers of participation, contentment, responsiveness, adaptability, diversity, resilience, and so on." (7). The distinction in the 'meaning' of architectural form that is referred to in those terms has been precisely identified earlier as "signification and significance," respectively (8). While it is important to stress this distinction, we think, however, that the autonomous consideration of value systems (significance) by an artificial designer with respect to his design activity can only be approached successfully (if at all in the foreseeable future) on the basis of our understanding and modeling of the more fundamental processes associated with a less involved interpretation of the design problem.

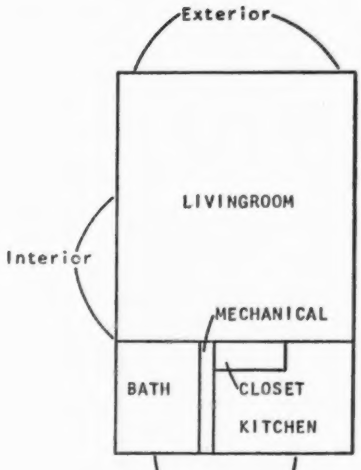
It is not easy to find such a description, because in an architectural concept the existence of some component elements is conditioned on the existence of certain relations encountered in the problem environment and vice versa. For example, there are efficiency apartments with an entranceway, and there are some without, there are some where one enters the bathroom from the livingroom, and there are some where one enters it from the entranceway. For an illustration consider the results of design experiments in Figure 1 and Figure 2. The geometric relations between 'Interior' and 'Exterior' in Figure 1 call for an 'ENTRANCE', whereas the relations in Figure 2 do not call for an 'ENTRANCE'. As a consequence, the 'CLOSET' can be adjacent to the 'ENTRANCE' in Figure 1, and has to be adjacent to the 'LIVINGROOM' in Figure 2.

In computer aided design the machine does not know anything about the object it is supposed to design, therefore the machine has to be provided with a crefully worked out 'explicit' problem statement (5)(9). This statement is highly reductionist since it has to omit significant aspects of the concept being communicated. In the course of an interactive man-machine dialogue, this statement often has to be rephrased several times by changing the constraints, until the machine can produce an acceptable solution. The designer's initial formulation and subsequent rephrasing of the problem statement, however, substantially amount to solving the problem. And right here is the upper bound on the extent to which computer aided design aids in design, because we do not think that the suggestions produced by current design aids are sufficiently



Efficiency Apartment

Figure 1.



Efficiency Apartment

Figure 2.

An 'efficiency apartment' is defined as a set of rooms some of which are optional. Each room, or each component part of a non-rectangular room is defined by the RANGE describing its area and dimensions and by its ADJ-LIST describing arrangements.

Take for example the livingroom 'LIVR'.

```
(RANGE                          ; identifier

   LIVR                         ; room name

   200.  260.  1200.            ; area

    15.   20.    40.            ; length

    10.   13.    30. )          ; width
```

Each of the triplets indicates a minimum value, a common value, and a maximum value.

```
(ADJ-LIST                       ; identifier

   LIVR                         ; room name

   ((EXTERIOR SP))              ; must be adjacent to

   ((ENTR CI) (INTERIOR CI))  ; must be adjacent to
                                  (list may be empty)
   ((MECHANICAL AC) (BATH CI)); should not be adj. to
                                  (list may be empty)
   ((KTCH CI) (CLST SP)) )    ; should be adjacent to
                                  (list may be empty)
```

This says that the livingroom always has to be spatially, 'SP', adjacent to the exterior, that it has to be adjacent to the entranceway or the interior of the building for circulation, 'CI', that it should stay away from mechanical space, so not to obstruct it, and the bathroom, and that it should try to be adjacent to kitchen or closet in that order. Each of the four categories in the ADJ-LIST can contain up to four entries, or it can be empty, 'EMPTY'.

Architectural Concept

Figure 3.

The current state of the concept is summarized in one statement for each room that is included in the current state. This statement is used by the region proposer, the design program, and the LOOK-AHEAD.

Take for example the livingroom 'LIVR'.

```
(REGION-GOALS                   ; identifier

   LIVR                         ; room name

   200.  391.                   ; area, from to

    17.   23.                   ; length, from to

    10.   17.                   ; width, from to

   EXTERIOR SP                  ; must be adjacent to

   NOT NOT                      ; (*)

   MECHANICAL AC                ; should not be adjacent to

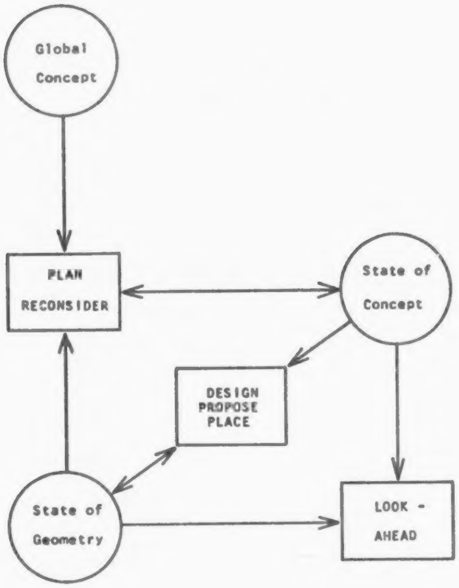
   NOT NOT )                    ; (* *)
```

(*) When the livingroom was designed the state of the concept included an entranceway, but the entranceway was not, 'NOT', as yet designed at that point in time. Hence the statement calls neither for an adjacency to interior space nor to the entranceway. Consider Figure 1-4.

(* *) None of those rooms to which the livingroom should be adjacent are included in the state of the design as yet.

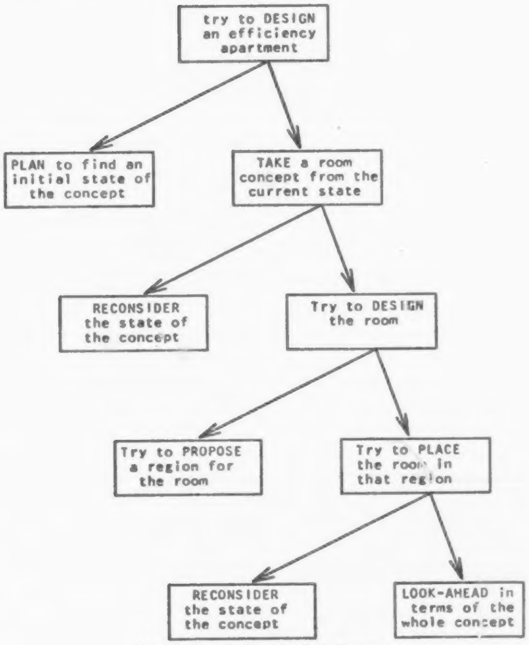
State of the Concept

Figure 4.


Global Concept
PLAN RECONSIDER
State of Concept
DESIGN PROPOSE PLACE
State of Geometry
LOOK - AHEAD

Flow of Information

Figure 5.


try to DESIGN an efficiency apartment
PLAN to find an initial state of the concept
TAKE a room concept from the current state
RECONSIDER the state of the concept
Try to DESIGN the room
Try to PROPOSE a region for the room
Try to PLACE the room in that region
RECONSIDER the state of the concept
LOOK-AHEAD in terms of the whole concept

Elements of the Design Process

Figure 6.

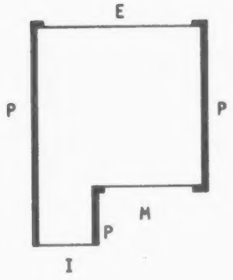


Figure 7.

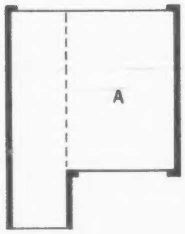


Figure 8.

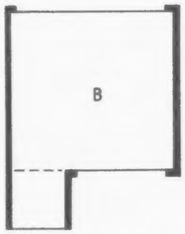


Figure 9.

persuasive to draw the user into an exchange of design ideas that could lead to new ideas (10).

Since there is no useful theory of designing, most computer aided design systems have resorted to optimization of an inadequate objective function as the primary mechanism in their search for a solution to make up for the lack of a more comprehensive design ability (5). Often the objective of the optimization effort in floorplan layout is nothing but minimization of the total traffic, or circulation cost, while observing a minimal set of geometric constraints. This is known as the backboard wiring problem in the O/R literature (11)(12)(13). Unfortunately, this objective, taken alone, is of secondary importance for many architectural design problems.

Another approach has been reported (14) which is based on a rigorous treatment of the planar graph representation of the adjacency requirements, called for in an explicit problem statement. This approach uses an exhaustive search strategy in a comparatively small search space to find all possible arrangements. In our opinion, this is not a useful way to think about the problem (10). Even worse, the class of approaches to the architectural design problem reviewed above obscures one of its central issues: the achievement of architectural order.

The problem solving structures hypothesized and modeled when exploring the human design process are useful for computer aided and automated design alike. In fact, this distinction is mainly a question of scale. However, the adherence to the early forms of computer aided design, motivated by the merits of man-machine interaction, seems to have hindered the search for an explanation of design proper.

Implementation

The program's capabilities and limitations can be illustrated to some extent. Examine how the program resolves decision conflicts and corrects decisions that turned out to be wrong during the automated design of the efficiency apartment shown in Figure 1. Basically, the program designs a room in three steps. First, it tries to propose an empty rectangular 'region'. Second, it tries to place the room somewhere in that region. Third, the program checks if what it just did is compatible with what remains to be done. If a failure occurs in any of the three steps the program will back up. Consider the over all goal tree in Figure 6. The design 'problem' consists merely of an outline of an area, the 'problem environment', consider Figure 7. Parts of that outline are designated as adjacemt to exterior space (E) for daylight, other parts of the outline are designated as adjacent to interior space (I) for access to the interior of a presumed building, and parts of the outline are designated as adjacent to mechanical space (M) to receive mechanical installations from the interior of the apartment. The remainder of the outline is designated to be a wall or partition (P). Although this is a rather sparse description of a design problem, the multitude of forms in which this may occur does present a hard problem to the artificial designer. Recall that this artificial designer is not provided with some particular explicit problem statement, but has to use its general knowledge in analyzing the problem environment to infer a suitable conception to guide its design effort.

Thus, PLAN is a program that examines the problem environment and subsequently makes various tentative decisions as to which rooms will constitute this particular apartment and what their area and dimensions will approximately be. Consider PLAN in Figure 5 and Figure 6. For the efficiency apartment, PLAN examines the empty design area to see whether there should be an entranceway leading from the interior (I) into the living room. In this case the program decides that there should be an entranceway because the design area is too narrow at the interior (I) for the livingroom to extend from the exterior (E) to the interior (I) as a rectangle. See also Figure 1. When attempting to design the livingroom, the program cannot decide whether 'region' A (Figure 8) or 'region' B (Figure 9) is more suitable for this purpose, because both regions meet the necessary and desirable conditions equally well. Those conditions are shown in Figure 4 and will be explained later. When the program uses region A, the livingroom will completely occupy that region. When LOOK-AHEAD subsequently tries to determine whether the solution can be successfully completed, LOOK-AHEAD finds soon that there is no way to connect the bathroom or kitchen to the mechanical space (M) now obstructed by the livingroom, consider Figure 8. This failure of LOOK-AHEAD to foresee a successful completion causes the program to back up so that the region proposer can propose region B (Figure 9) instead of region A.

At this point a brief remark about PLANNER seems in order. PLANNER is a language for the creation and description of problem solving schemes (15). The PLANNER language is oriented towards the accomplishment of tasks. A subset of that language has been implemented as Micro-PLANNER (16) on the Artificial Intelligence Laboratory computer at M.I.T. in LISP (17). In a PLANNER program a task is broken down into goals and subgoals. When a goal is activated, it may be satisfied by a number of data fitting the goal pattern or by a number of procedures having the same effect. The data and procedures do not have to be referenced explicitly but instead are accessed just by matching patterns. PLANNER provides a backup mechanism, so that when a failure occurs (i.e. a goal cannot be achieved) PLANNER can backtrack, restoring the previous state of the world as it goes, until it finds another procedure or data to satisfy its goal. Different procedures that have the same effect, i.e. the same goal pattern, may be written as PLANNER theorems and can be invoked by their goal patterns, to be tried in turn. One may fail, the other one may succeed depending on the circumstances since the two procedures have different ways of accomplishing their goal. For example, the first procedure may not be able to design a room as a rectangle, but the second procedure may be able to design it as composed of two adjacent rectangles. Thus the program often has the choice among different ways to accomplish a goal. These ways correspond to the branches of the conceptual goal tree (4) in the hierarchical control structure of PLANNER. In a heuristic program some of the branches of the problem tree lead to failure, others lead to success. Since PLANNER has an automatic backup mechanism, it can recover from failure and will eventually succeed, at least in principle, if there is a branch leading to success. Yet, this blind search may take longer than one is willing to wait, or the accumulation of the tree (a record of the problem solving history to be used for backup) may exceed the machines core allocation. In any case, to avoid this, one has to apply subject knowledge, heuristics, to very selectively direct the search for a solution. For a certain class of heuristics considered here, one can often write a more sophisticated procedure by including more information and by elaborating the computation. There is always that unresolved remainder, as in the illustration of Figure 7 through Figure 9. When the application of various heuristics to a decision situation results in a preferential ranking of those options, one may speak about the heuristic ranking of those options.

A first step in the search for a theory of design might be the formulation of the design problem which is tractable at this point in time.

For the purpose of this study,

Design is the
a) geometric realization of
b) concepts in response to a
c) unique problem environment with the
d) intention to achieve form (18).

"Creative" innovation of design concepts has not been considered, because we have no clues to an exact understanding of this phenomenon that might have yielded to modeling at this time. Random generation and testing is a rather useless notion to explain what we mean by 'creativity'. Only the first three points of this formulation of the design problems have been implemented to reduce the complexity of the task.

Let us consider the idea of an architectural concept in more detail. A global architectural concept describes a variety of quite different configurations. Figure 3 illustrates this. A global architectural concept constitutes the set of all possible forms, when it is well formulated. Our program knows that an efficiency apartment always consists of a livingroom, a kitchen, a bathroom, and a closet, and that it sometimes also has an entranceway, and sometimes a mechanical space which is shared by bath and kitchen. The program further knows about desirable, possible, and undesirable arrangements of the rooms in the apartment as expressed by the adjacency relations. Finally the program knows if a room has to be rectangular, or if it can also be composed of two spatially adjacent rectangles. It also knows about the possible and desirable range of area and dimensions of the rooms or their component parts. By the ordering of entries in its adjacency lists, 'ADJ-LIST', the concept exhibits a preference for certain arrangements and room shapes, since they are tried first. (But the program does not know about the relative importance of the 'component rooms', and it does not know what they might mean to a person.) PLANNER procedures can use this data to determine a suitable state of the concept (Figure 4) by relating the data to the state of the geometry. Figure 5 shows the flow of information between the three expressive domains (6) which are the global architectural concept, the state of the concept, and the state of the geometry. All three domains contain a more or less specific description of the referential domain (6): floorplan of 'efficiency apartment'.

The geometric realization of an architectural concept (global data) in a particular design area (problem data) requires three sets of procedures. In Figure 5 data sets are shown as circles while programs are shown as boxes.

First, procedures have to relate the global architectural concept to the design area to determine an initial state of the concept, see PLAN in Figure 5 and Figure 6. This state, a consistent set of REGION-GOALS statements, serves as a more specific guide in the search for a solution until reviewed and revised. Figure 4 shows part of the concept.

Second, procedures have to relate the state of the concept to the state of the geometry to make tentative design decisions. There the program makes global observations of the state of the solution to determine an acceptable configuration for the room the program wants to design. When the program is satisfied it will put the room down and examine its properties. During this process the program is exclusively guided by the current state of the concept, as far as it pertains to this particular room, as described in its REGION-GOALS statement.

Third, after putting the room tentatively down, other programs will review and if necessary revise the state of the concept with respect to the new state of the solution, consider Figure 5 and Figure 6, RECONSIDER. Then LOOK-AHEAD will use the remainder of the concept to look ahead in terms of all rooms still to be designed and in terms of the new state of the geometry, LOOK-AHEAD does not design ahead. It only makes more or less sophisticated predictions on which of the rooms still to be designed might go where, and if the rest will fit into what is left over. Unfortunately, when LOOK-AHEAD 'fails' it does not return specific information on where it failed and for what reason. This problem of 'fault assignment' is very hard to solve. Since many highly interrelated decisions are made in designing it is difficult to say which one of them is 'really' responsible for the failure and how it should be revised. LOOK-AHEAD has been designed such that it will only fail when the current state of the solution geometry is false, i. e. the geometry will not allow a completion of the design task (supposing, of course, that LOOK-AHEAD itself is correct). If LOOK-AHEAD succeeds, the design process will move on. If it fails, the process will back up under the hierarchical PLANNER control structure undoing what it did, until the program finds an alternate way to accomplish its goal. Then the process will resume its way on down a new branch of the conceptual goal tree (4) (envision the tree to be bottom up). As it turned out, the concept of look-ahead has been stretched well beyond its capacity, particularly in conjunction with a too loosly structured plan (the set of REGION-GOALS statements).

Evaulation

Some principal objections to an investigation of this type have been raised. It has been argued (19) that the structure of the human design process cannot be found, because the essence of a designer's ability, "his sensitivities", "are not themselves processes". This assertion has not been supported other than by characterizing the designer's sensitivities as "fragile" and "arbitrary". We do not think that they are arbitrary, but rather that we do not understand principles of creative thinking very well, regardless whether in science, art, or architecture. Therefore we are reluctant to characterize the designer's ability as some sort of a random event. For a certain line of argument in issues of intelligence, it is common practice to postulate some random process or an even more elusive concept, when insight into the thought process is beyond reach; be this for intellectual or psychological reasons (20). This position will almost necessarily arise from the belief that designing is infinitely complex, and that the synthesis of form seemingly happens in the brooding mind, rather than being actively pursued. We think, however, that the foregoing is not a tenable position. Other areas of 'creative' problem solving where humans do not know exactly how they think have been modeled successfully such as symbolic integration and an area of organic chemistry (21). These programs have in some sense even exceeded the ability of professionals. It is important to discuss the comparison between design and mathematics, because for some people it is a source for the belief that design can be thought of in the same way as mathematics; the 'uniformity' of thought processes in various problem domains is presupposed (22). For others, the comparison serves to conjecture that design might be an activity of fundamentally different nature (2). This dispute is somewhat vacuous since there is no hard evidence to support the argument. However, the comparison offers an opportunity to consider some characteristics of environmental design in the context of computer models.

At first glance, this might appear as a valid comparison in two ways. In designing, as in symbolic integration, intricate structures have to be created and the exact nature of the problem solving process is not known. Although we know more about the steps involved in symbolic integration, one could argue that our ignorance about the design process and about design concepts may not be due to the inherent nature of the design problem, but rather to the traditional way of thinking about it. However, we observed already that in environmental design, as opposed to mathematics, the structures created have to attain various ill-defined properties to qualify as 'form' (18). An integral, in a sense, implies its solution, whereas this is less so for a real world design problem (as opposed to an artificial toy problem). In the world of computer aided design, this characteristic of the design problem has led to the unbalanced formulation of design concepts and design procedures which stress certain more easily formulated specifications, and neglect the aesthetic and social significance of the structure (7). We have to ask if these unfavourable characteristics of the problem are insurmountable, in principle, or if they are a result of the state of the art. That is, are these ill-defined properties more elusive than those, the chemist or the mathematician has to deal with. We do not see a reason that would support such a position. Further, consider a common conceptual basis that seems to be shared by the varous attempts to employ a computer intelligently in design. It has been widely accepted that effective symbolic descriptions are of central importance in the design of programs that are intended to exhibit sophisticated behaviour (6). All aspects of environmental design that are accessible to some form of description, e.g. in natural language, are in principle accessible to computation. While it is true that we do not have a suitable language to express many architectural ideas effectively, it should nevertheless be possible to invent such a language. We do not claim that we can completely understand designing with the conceptual tools discussed here, but on the other hand it seems premature to postulate an upper limit on what can be understood and modeled, since we have barely started to work on the problem. The question, to what extent the comparison between modes of thinking in science and design is enlightening, remains open to speculation and further analysis.

As to the model, it is worthwhile to consider some necessary and desirable properties of a proposed theory of design for the purpose of evaluation and validation. To construct an artificial designer we started to model a simple hypothesis about the structure of the human design process, as it appears to us. As long as we are only interested in the productivity of the model it is sufficient to consider a variety of input output pairs to evaluate the model's performance. But if we model a hypothesized human problem solving process in order to find a computational approximation to that process, we face the more serious problem of validating the model's interior structure (23). Since there are theoretically a great number of programs that could produce the same set of I/O pairs, it is not sufficient just to consider the I/O pairs to validate the model.

An evaluation should be done in terms of productivity. We observed already that the productivity of the model is limited by the lack of many design concepts and particularly by the ladk of a more capable design process than we have implemented. No global properties of a potential design are considered in the model, although we know that they are important for designing, particularly in the phase of conception and planning of the more detailed design. This has been left out because the realization of global properties will often involve the simultaneous consideration of the relative position and shape of several elements of a concept, or some other equivalent mechanism. The simple sequential placing of one element after the other, without some sort of a plan in suitable geometric terms (or in abstract terms), or without a good facility to withdraw placements and rearrange, is too blind and inflexible to succeed in general.

When considering the validity of the model as a computational approximation to human design intelligence, we find that we cannot make claims to that effect. Although we used what might seem like a human method, it is uncertain, nevertheless, to what extent introspection and certain observations can reveal how humans really think. This is particularly true for various low-level operations involved in 'seeing' or 'picture interpretation' that humans do unconsciously. We do not know anything about the data structures or computations that might be engaged in those low level activities; however, there exist various schemes for machine simulation (6). It seems, however, that we understand a few high-level principles of human design intelligence to some extent, so that we can formulate a hypothesis in terms of a program. When the program works well, we tend to believe that we have found an approximation to the human thought process. We would then claim plausibility but not certainty. However, our model does not work too well. We have pointed out the difficulties and some of the reasons that occured to us while building and testing the model.

Conclusion

Besides the goal to construct an artificial designer, we expect to improve our understanding of human designing with this work. By constructing a design intelligence that has some resemblance to human designing, we have gained a more precise understanding of content and organization of knowledge to be engaged in the performance of such a task. While such hypothesis are more or less plausible, since they are derived from introspection and certain notions about human intelligence, testing of the model shows exactly where they seem to approximate human thinking, and where such hypotheses fail to explain designing. We have pointed out those instances. After our experiment, it turns out that we need a much more structured scheme as to form and content of knowledge and the way it is used in designing. Specifically, a future program will have to use some form of successive approximations to the solution before a final result is formulated, similar to what the human designer does. The approximations are conceivable in geometric terms, or/and in an abstract sense as reductions of the conceptual search space, which do not exclude prematurely any of the 'good' solutions. In a task domain like design, where we use a lot of context dependent knowledge without some complete unified theory, we should not expect to find very compact and universal programs.

Appendix: Implementation

The model was implemented in Micro-PLANNER (16) on the time shared PDP-10 computer of the Artificial Intelligence Laboratory at MIT. The program uses an allocation of 98,000. words (36 bits) of core memory, of which about 70,000. words are for the program, and the rest for data and the problem tree. The problems executed in about 15 minutes. when the job stayed in core throughout execution time.

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MATHEMATICAL EVALUATION AND OPTIMIZATION OF THE THREE DIMENSIONAL HOSPITAL LAYOUT PROBLEM

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Abstract

This paper presents the mathematical structure and design potential of a computerized layout model developed to solve the specific problems inherent in hospital design. The model not only arranges hospital activities in three-dimensional space, but also locates stairways and elevators to achieve "optimum" operational efficiency.

Problem

Several recent studies in hospital design have concentrated upon the goal of reducing non-direct care demands made upon the hospital professional staff.(1) It has been the general assumption of these studies that if the function of acute general hospitals can be broadly stated as the satisfaction of patient needs and restoration of patient health, the patient-nurse-doctor relationship is of primary importance. It has similarly been assumed that if the level of patient care improves with the time available for such care, hospital efficiency can be considered to be inversely related to the percent of time the professional staff must spend on non-professional duties. Obviously, one cannot be involved in direct patient care while going from one room to another. It is likewise obvious that the longer the average total distance the medical staff must travel during a typical day, the shorter the time available for patient care becomes.

The traditional hospital, however, has typically taken the form of the "hotel-apartment" consisting of long double loaded corridors, supported by service and nursing facilities at specific points along the corridor. Extremely long travel distances between nurses' stations service facilities, and patients' rooms are, thus, characteristic of this plan. In fact, a study by Sarvis indicates that as much as forty percent of a nurse's time in such double loaded corridor facilities is spent in transit. (2) Quite obviously, the potential savings in operational cost for the nursing unit alone are tremendous. Considering the fact that two-thirds of a hospital's operating expenses are attributable to the salaries and and wages paid to employees, even a slight reduction of the transit time factor could have a significant economic benefit for health facility functions as a whole.

Objective

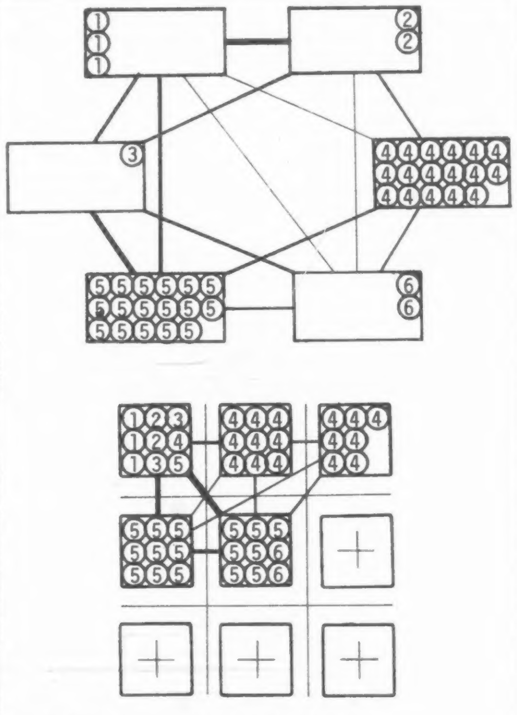
If one accepts as his goal the improvement of hospital efficiency, where efficiency is defined as the relative measure of patient care effectiveness and patient care cost, one's planning concerns are necessarily limited to only those factors which influence this effectiveness-cost scale. If we further assume that our concern lies primarily with functional links between functional areas (activities) within the hospital as these links affect efficiency, we can define our major design considerations as "efficiency influencing functional linkages". Given a schedule of required activities, our design objective becomes the determination of the optimum relative grouping of these activities as defined by the various links between them.

Structure

Space within any given hospital can be divided two ways. First, it can be divided into non-specific sub-departments or zones. These zones would then represent non-functionally distinguishable gross divisions of the total floor area. A second way the space could be reduced would be in terms of specific functional areas or activities. These activities would represent categorized, functionally distinguishable divisions of the total area. As such, the inter-relationships within and between the activities would define the cumulative function of the whole facility. That is, personnel travel, environmental incompatabilities, mechanical delivery device, and similar functional relationships, would occur between activities rather than between zones. The zones would, in this system, simply serve to physically "house" the activities.

For any pair of activities within an existing hospital there can be tabulated an average number of trips made by hospital employees between those two activities within a specified time period. Trip generation studies in hospital design indicate that within certain definable ranges an expected number of trips between activity pairs in new facilities can be estimated with reasonable accuracy based upon data from existing ones. (3) If we know certain basic operating policies of a proposed health facility, a trip frequency distribution matrix for activity inter-relationships can then be established.

If the physical locations of all zones are assumed fixed while that of the activities is assumed to be variable the hospital layout can be studied as an assignment problem of activities to zones. For example, if six activities are required in a given space and if this space is divided into nine zones, our design problem would be to assign the six activities to the nine zones according to some predetermined design objective relating to all links between the activities. (See Figure 1) If the distance between each pair of points is assumed to be equivalent to the rectilinear distance between the centroids of their respective zones we can calculate for a given layout the distance between individual activity locations. Similarly, if we know the number of trips necessary between each pair of activities and a cost per unit distance associated with each trip the cost of operation can be determined for specific layouts.



Activity Areas and Associations
Activity Assignment to zones

Figure 1

Significantly, the number of trips between two activities is generally not a function of the distance between them. With the exception of trips between patient rooms, the expected number of trips between any two activities can be considered a constant. For example, intuitively it would seem logical that the number of trips from a nursing station to a patient room would vary inversely with the distance the room was from the nursing station. However, studies by Freeman indicate that the degree of sickness of the patient and not his room location determine the number of inter-activity trips. (4) Similar relationships exist between most other activity pairs. (5)

Criteria
Our design goal has been stated as the improvement of hospital efficiency. We have further defined efficiency in both human and economic terms. If the optimization procedure suggested results in increased economy of operation without a reduced level of patient care or if the level of patient care is increased without an increase in the cost of operation, our goal has been positively approached. That is, if we can decrease cost or increase efficiency, or any combination of the two, through the assignment of activities to zones a methodology has developed which is supportive of our original design goal. Since previous studies indicate that additional time made available to the existing hospital staff typically translates into increased time spent with patients (6) and since one accepted measure of the level of patient care is this direct care time, economy of operations and patient care level represent a trade-off function in themselves. It is therefore assumed, for the present study, that economy of operations can be considered a sufficient measure of both human and the economic aspects of our design objective. As such, it becomes the major design criterion for modeled optimization.

Model Development
If, for our purposes, a trip is defined as the journey made by a person within a building from one activity to another, and if the locations of the activity of trip origin and the activity of trip destination are known, the "cost" for a given trip can be determined. This "cost" is a function of both the distance between origin and destination and the wage level of the "average" person making the trip. The sum of all such inter-activity trip costs in a spatial layout represents, for a given time period, the cost of operation attributable to transit.

Since for each pair of activities in a hospital there can be established an expected number of trips typically "generated" between the two activities per time period and since the number of square feet allocated for each activity unit is known, a trip production coefficient can be established for the association between each activity set. This trip production coefficient, measured in the number of trips generated per square foot of activity j per square foot of activity l per year, represents the product of the expected number of trips generated between activities j and l per year, 1/area of activity j, and 1/area of activity l. The sum of all such trip generation coefficients establishes for a given spatial assignment of activities to zones the inter-zonal trip distribution for the resulting layout. For any allocation solution, then, there can be established an associated cost of total inter-zonal travel as generated by specific activity assignments to zones. If this cost is significant within the total context of hospital economy, a reasonable design objective might be to minimize this cost subject to other cost and non-cost related considerations. Stated mathematically this objective becomes:

$$\text{Min. } z = \sum_{i=1}^{m} \sum_{k=1}^{m} \sum_{j=1}^{n} \sum_{l=1}^{n} x_{ij} \cdot x_{kl} \cdot p_{jl} \cdot d_{jl} \cdot t_{ik} \quad (1)$$

$$\text{s.t.} \quad a_i = \sum_{j=1}^{n} x_{ij}.$$

$$b_j = \sum_{i=1}^{m} x_{ij}$$

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

Where: x_{ij} = number of square feet of activity j in zone i.

p_{jl} = trip production coefficient between j and l, number of trips/square feet of j/square feet of l year.

d_{jl} = cost of travel/second between activities j and l.

t_{ik} = travel time in seconds between zones i and k.

a_i = number of square feet in zone i.

b_j = number of square feet in activity j.

m = number of zones.

n = number of activities.

Values for p_{jl}, d_{jl}, t_{ik}, a_i, b_j, m, and n are known; values for x_{ij} are derived from the solution of the equation; x_{ij} and x_{kl} are the same matrix.

Equation 1 represents a general form of the quadratic assignment problem and is similar to that outlined by Nugent, Vollman, and Ruml.(7) The problem differs from the classic "0,1" location problem only in that

$$\sum_{i=1}^{m} x_{ij} \text{ and } \sum_{j=1}^{n} x_{ij}$$

do not necessarily equal to one. Instead, x_{ij} may assume any values so long as

$$\sum_{i=1}^{m} x_{ij} = b_j \text{ and } \sum_{j=1}^{n} x_{ij} = a_i \text{ where } a_i \geq 1 \text{ and}$$

$$b_j \geq 1.$$

That is, for a given solution, one activity may be allocated in varying amounts of several zones. Similarly, certain zones may contain several activities.

The optimal assignment of activities to locations is a combinatorial problem that remains computationally unresolved. None of the several optimal producing procedures is computationally feasible for any but very small problems.(8) The difficulty in its solution is a product of both the immense number of possible arrangements which have to be explored to find an optimum and, for equation 1, the non-linearity of the objective function. Since, ignoring mirror images and rotations, n facilities can be assigned to n locations in n! ways, total enumeration of all possible layouts must be considered computationally infeasible. For example, Dickey, Conner, and Hopkins note that the number of possible arrangements for a 15 activity 15 zone problem is roughly 10^{12}. For a computer which could evaluate 10^5 arrangements per second, it would take four years to check all the possible solutions to the problem.(9)

4.2 Linear Solution Procedure for the Non-Linear Transit Model(10)

If we assume an allocation solution (values for x_{ij}, where $x_{ij} = x_{kl}$), we can with equation 1, calculate the total cost of operation attributable to transit. Similarly, if we know a complete allocation solution we can, with equation 2, calculate a "potential" cost of operation attributable to the allocation of one square foot of activity j to zone i assuming for each j in i that the location of all activities in all other zones is known. That is, we assume for equation 2 that x_{ij} and x_{kl} are not the same matrix and that while we know the values for x_{kl} we do not know the values for x_{ij}. (An apparent contradiction which, for now, must simply be accepted.) If we then solve equation 2 for all j in i, a cost matrix c_{ij} is developed which represents the cost of operation resulting from the allocation of one square foot of activity j to zone i.

$$c_{ij} = \sum_{k=1}^{m} \sum_{l=1}^{n} x_{kl} \cdot p_{jl} \cdot d_{jl} \cdot t_{ik} \qquad (2)$$

Where: c_{ij} = the cost of travel generated by the allocation of one square foot of activity j to zone i.

x_{kl} = number of square feet of activity l in zone k.

p_{jl} = number of trips generated/square foot of activity j/square foot of activity l/year.

d_{jl} = cost per second of travel between j and l.

t_{ik} = time in seconds required to make a trip from zone i to zone k.

m = number of zones.

n = number of activities.

Values for x_{kl}, p_{jl}, d_{jl}, t_{ik}, m, and n are known values for c_{ij} derived from the solution of the equation.

Assuming, temporarily, that each c_{ij} found by equation 2 represents the cost of locating one square foot of activity j to zone i, our objective function reduces to a linear transportation problem. That is, since equation 2 gives us the cost of allocating one square foot of activity j to zone i, an interim solution for the allocation x_{ij} in equation 1 is possible under the following mathematical procedure:

$$\text{Min. } z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} \cdot x_{ij} \qquad (3)$$

$$\text{s.t. } \sum_{j=1}^{n} x_{ij} = a_i \quad \text{and}$$

$$\sum_{i=1}^{m} x_{ij} = b_j$$

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

Where: z = the cost of operation attributable to transit for the given spatial allocation represented by all values of x_{ij}.

c_{ij} = cost of allocating one square foot of activity j to zone i.

x_{ij} = allocation solution - square feet of activity j in zone i.

a_i = number of square feet in zone i.

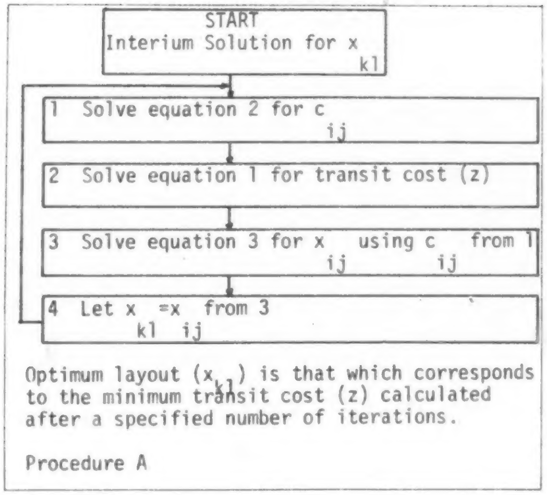
b_j = number of square feet needed of activity j.

m = number of zones.

n = number of activities.

Values for c_{ij}, a_i, b_j, m, and n are known; values for x_{ij} are derived from the solution of the equation.

The resulting solution x_{ij} represents the optimum economic placement of activities in zones given c_{ij}. However, the c_{ij} matrix used in the computation of equation 3 is derived from the allocation solution x_{kl} assumed in equation 2. The two solutions may or may not be the same. If $x_{ij} = x_{kl}$ for all i, j, k, l where i=k and j=l then the solution to equation 3 represents the optimum activity assignment. However, if $x_{ij} \neq x_{kl}$ then an iterative procedure must be employed to converge upon the optimum activity arrangement.


START
Interium Solution for x_{kl}
1 Solve equation 2 for c_{ij}
2 Solve equation 1 for transit cost (z)
3 Solve equation 3 for x_{ij} using c_{ij} from 1
4 Let $x_{kl}=x_{ij}$ from 3

Optimum layout (x_{kl}) is that which corresponds to the minimum transit cost (z) calculated after a specified number of iterations.

Procedure A

Figure 2

Three Dimensional Design

To this point, inter-zonal travel time has been computed according to the rectilinear distance between zonal centroids. However, circulation which necessitates vertical movement does not necessarily conform to the standard measure of three dimensional rectilinear distance. Instead, if vertical movement is assumed to be provided only by elevators, all trips from zone i to zone k, where i and k are on different levels, would normally go through the zone of location of elevator s, where x is the elevator which provides the shortest distance between i and k. Travel time from i and k would then equal to the sum of the travel time from i to s on the level of k, the time within s, and the travel time from s on the level of k to k.

Vertical circulation within the hospital is generally provided by stairways and elevators. Both of these vertical transit modes can be considered as activities within the facility. As such, they are subject to relative allocation just as are other activities. However, unlike the activities discussed in the previous sections, the trip production coefficient between s, where s is a vertical transit mode, and all other activities varies with specific allocations and it is different for each floor. That is, the number of trips generated by a vertical transit mode allocated to a specific zone is not a function of the number of square feet assigned to the zone, but rather it is a function of the number of trips for which s provides the shortest distance between other zones.

If we let w_i equal to the vertical coordinator of zone i and if we categorize all inter-zonal trips into one of the following three types:

1. Trip originating and ending on the same floor (excluding those to and from vertical transit modes);
2. Trips originating and ending on different floors (excluding those within vertical transit modes);
3. Trip to, from and within vertical transit modes;

and if, for simplicity, we assume all vertical transit is provided by elevators, then we can state the objective function for the three dimensional design problem as follows:

$$\text{Min. } z = \sum_{i=1}^{m} \sum_{k=1}^{m} \sum_{j=v+1}^{n} \sum_{l=v+1}^{n} x_{ij} \cdot x_{kl} \cdot p_{jl} \cdot d_{jl} \cdot t_{ik} + \quad (\text{for } w_i = w_k \ \& \ j>v)$$

$$\sum_{i=1}^{m} \sum_{k=1}^{m} \sum_{j=v+1}^{n} \sum_{l=v+1}^{n} x_{ij} \cdot x_{kl} \cdot p_{jl} \cdot d_{jl} \cdot t'_{ik} + \quad (\text{for } w_i \neq w_k \ \& \ j>v)$$

$$\sum_{i=1}^{m} \sum_{k=1}^{m} \sum_{j=1}^{n} \sum_{l=1}^{n} x_{ij} \cdot x_{kl} \cdot q_{ijkl} \cdot t_{ik} \quad (\text{for } j \geqq v) \quad (4)$$

$$\text{s.t. } a_i = \sum_{j=1}^{n} x_{ij}$$

$$b_j = \sum_{i=1}^{m} x_{ij}$$

$$\sum_{i=1}^{m} a_i = \sum_{n=1}^{n} b_j$$

The corresponding linear equation for the above non-linear objective function is as follows:

$$c_{ij} = \sum_{i=1}^{m} \sum_{l=v+1}^{n} x_{kl} \cdot p_{jl} \cdot d_{jl} + g_{jl} \cdot t_{ik} + \quad (\text{for } w_i = w_k \text{ and } j>v)$$

$$\sum_{k=1}^{m} \sum_{l=v+1}^{n} x_{kl} \cdot p_{jl} \cdot d_{jl} \cdot t'_{ik} +$$

$$\text{(for } w_i \quad w_k \text{ and } j \ v\text{)}$$

$$\sum_{k=1}^{m} \sum_{l=1}^{n} x_{kl} \cdot q_{ijkl} \cdot t_{ik}$$

$$\text{(for } j_{=}v\text{)} \qquad (5)$$

Where: $t'_{ik} = t_{is_{w_i}} + t_{s_{w_k}k} + t''_{w_i} + \sum_{r=w_i}^{w_k -1} t'''_r$

g_{jl} = non-operational cost association between activities j and l.

q_{ijkl} = trip production and cost coefficient = number of trips times trip cost/second/square feet of j in i/square feet of l in k/year where j is a vertical transit mode activity.

v = number of activities assigned as vertical transit modes. For a facility of four floor levels each vertical transit mode would require four activities, one allocated to each floor. Thus, for a four floor facility with two elevators, v would equal to eight.

w_i = floor level of zone i.

s_{w_i} = zone of location of vertical transit mode s on level w_i.

t''_{w_i} = expected vertical transit mode waiting time on floor w_i.

t'''_r = expected vertical transit mode service time between floors r and r + 1.

All previously used variables retain their original definitions as given in equations 1, 2, and 3.

The optimization strategy for the three-dimensional model (Procedure B) proceeds similar to that described in Procedure A with equation 5 being used in step 1 and equation 4 being used in step 3.

The actual mathematical program utilized in the computerized model is significantly more complex than is presented here. Due to the inclusion of probability functions for vertical mode choice (stairways vs. elevators) and due to the inclusion of certain environmental design constraints the full objective function is substantially more cumbersome. For the present study, however, equation 4 can be considered a sufficient mathematical representation of the hospital transportation problem.

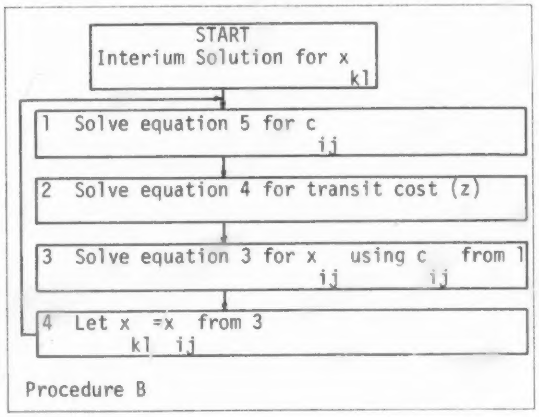

START
Interium Solution for x_{kl}
1 Solve equation 5 for c_{ij}
2 Solve equation 4 for transit cost (z)
3 Solve equation 3 for x_{ij} using c_{ij} from 1
4 Let x_{kl} =x_{ij} from 3
Procedure B

Figure 3

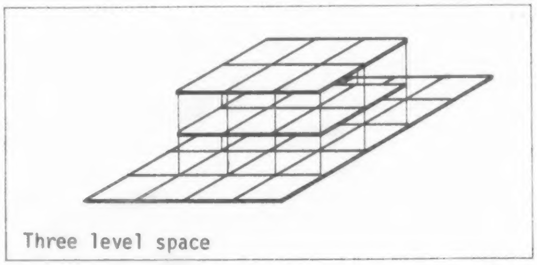


Figure 4

The Multi-Level Hospital

Hospitals have traditionally been designed with vertical towers providing the major circulation routes. The main form determinant, with this approach has been the "service core" around which units of various shapes have been vertically stacked. Adjacent to the nursing wing there has usually been a "service wing" in which ancillary departments also have been stacked. To go from one activity to another in such a scheme quite often would require the use of an elevator. Such travel would usually necessitate at least a short waiting time at the floor level of trip origin and a between each floor service time of from 15 to 20 seconds. The expected waiting and service time, naturally, would translate into a substantial increase in the travel time between activities separated vertically. Thus, although the design itself was physically more compact, its actual operation often translated into the transit cost equivalent of a much larger horizontally planned area.

Figure 4 illustrates a 32 zone, three-level space in which the following hospital activities could be located in a wide variety of ways:

a. nursing units (2 at 50 beds each)
b. emergency suite
c. surgery suite
d. radiology suite
e. delivery suite
f. pharmacy
g. laboratory
h. business office
i. medical records
j. admissions
k. administration
l. housekeeping
m. central storage - supply
n. maintenance
o. dietary

The configuration and size of the space defined in Figure 4 is specifically designed so as to facilitate modeled design in any number of horizontal and vertical patterns. The lowest of the three levels (A) is large enough to accommodate all the activities. The second and third levels (B and C) are each large enough to accommodate both nursing units or any combination of other activities.

When programmed to optimally arrange these activities into the space defined by Figure 4, the proposed model consistently restricted itself to one level rather than developing vertically about an elevator "core" as is more commonly done in practice. Throughout an entire ten iteration optimization procedure the model made no effort to expand vertically despite the ability to do so by way of an elevator core with an expected waiting time on each floor of 25 seconds and an expected service time of 20 seconds between each floor.

When the same activities were arranged in a typical broad based but vertical nursing "tower" (designer imposed initial values for x_{kl} in equation 5), the model immediately removed all activities from levels B and C and again arranged the entire facility on one level in a plan quite similar in transit cost to the "optimum" design described previously. However, the cost of operation calculated for the initial designer imposed three-level solution was more than 20 percent over that for the same activities located "randomly" on one level. Before a vertical design even began to be roughly equivalent to a horizontal one, the expected waiting time at each floor level had to be reduced to less than ten seconds and the service time reduced to less than five.

The same activities allocated to a smaller total space than that defined in Figure 4 tended to concentrate on as few levels as possible. Where multiple elevator shafts were provided, the model tended (strangely enough) to spread these shafts apart rather than group them in some central location. This decentralization of elevators, however, resulted in only slight reductions in total transit cost. The vertical plan was still unable to reasonably compete with the horizontal plan for the prescribed activities. In fact, the cost of operation for the multi-shafted vertical design (3 levels) is some 40 percent higher than the "optimal" one-level design.

Validity

It would appear that the study results reported here are highly contingent upon reliable trip production coefficients. In actuality, however, the relative merits of horizontal and vertical planning can be explored without even assigning values to p_{jl} in the model equations 4 and 5. The controlling factor in this study, in fact, is the sum of the travel times for each trip type produced. It is true that the general methodology upon which the proposed model is developed is dependent upon the availability of reliable and consistent trip statistics. However, the particular application proposed here is not so restricted.

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COMPUTER-AIDED HOSPITAL DESIGN

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The application of computer-aids to the design of hospitals is one of the oldest applications of computers to architectural problems and, at the same time, has been the most misleading. This is because of the nature of hospital design: it is characterized by many variables and a large number of functions, all of which are accountable by machines, but not by humans. There are so many known chunks of information that an unequivocal need for the computer can be established. At the same time, though, this vastness of information leads to the erroneous premise that the design of hospitals enjoys the availability of "complete" information. This untenable supposition insinuates optimization techniques for the handling of the design problem. And they don't work.

These techniques fail because they require degrees of specificity and completness which are untypical of the design process, particularly at the early stages of a problem. Not only do architects hold vague notions about design criteria, but doctors characteristically are not very facile with their own hospital needs and functions. Even if doctors could articulate exacting criteria, it is only partial information, and the optimization of partial information has little merit.

Consequently, we have chosen an approach to computer-aided hospital design which handles criteria in a fashion that presumes large amounts of missing information. The information is missing because there are certain things that the participants (doctors and designers) don't know or they don't know that they ought to know. As a result, we propose a solution generating system which simulates missing information. The computer does not do this through "default options", the initial prejudices of the system's designers. It achieves this through a probabilistic model of the design process.

In the limiting case, we postulate a machine which is inexperienced and uncommitted (a "tabula rasa" interacting with a designer who is equally innocent of the specific problem but highly influenced at a general level by previous experiences. The interaction is limited: the machine acts as a proposer of alternatives and the designer acts as the critic. The interaction between designer and machine can commence with the machine fabricating missing information and with the designer able to proceed without exacting specifications. The scenario starts off with the machine presenting totally absurd solutions, for example: boiler rooms find their way into main lobbies and operating rooms are intermixed with kitchens. The designer must be patient, because, in fact shortly, the system gains credibility by converging upon good solutions in response to his punishments and rewards. After a few negotiations with a human partner the machine achieves a certain stability and establishes simple relations among elements of the problem.

The machine interprets the man's comments in two manners: 1) explicitly, through categorical commands to do "this" or "that"; 2) implicitly, through tentative statements that "such-and-such" is good or bad. Eventually, the system acquires a set of relationships among "functional elements". Some of this information can be transferred to other hospitals' problems and some might even be transposable to the design of hotels, schools, residences, and the like.

One might mistake this approach for a simulated evolution or even an artificial intelligence. But it is neither. The method exhibits improvement over time by disturbing a probabilistic distribution of random numbers. This affords the machine the ability to converge upon tendencies and biases while allowing for exceptional cases to occur. To some extent it is an antagonist, disobedient and contradictory. But it does guarantee a design environment free of complacency and it can lead to design alternatives ultimately attributable to neither the man nor the machine alone. In

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effect, it is an interim step to artificial intelligence.

The opportunity to test these notions was found in a Washington, D. C. Children's Hospital project contracted to the Leo A. Daly Company, Arthitects and Engineers. At the onset of the project, it was assumed that the actual hospital design would be tackled without the use of the machine and that the computer research would be treated as a parallel effort. Any benefits that the hospital could accrue from the data handling system or the generating system would be considered fortuitous. This means that the computer programs have been able to benefit from "real" data while not having to exhibit design excellence. After all, when one teaches a young child chess, one does not expect him to play a championship game after the first instructions. Instead, one is happy if he will play by the rules.

Similarly, the present computer programs deal with a smaller number of realtionships than they should, they handle only stylized commands, and they are laden with "bugs". But the feasibility is proven and the directions of refinement and development are evident.

The present experiment runs on a time-sharing system which has permitted cooperation between terminals in Washington and Boston, via a machine in Philadelphia. It has been implemented in BASIC and PL/I with four separate modes: DATA, SPACE, SITE, and ENVELOPE.

DATA mode is for initializing and updating requirements such as square footages, costs, cubic feet of air per minute, and so on. Operational elements are ordered in a hierarchy of four levels where the "lowest" level includes all the hospital functions regardless of the organization of higher levels. One can treat these sets as groups (interrogating, appending, deleting) or manipulate them at the lowest level where the stored data resides. Actual changes in data occur at this lowest level since the higher levels only represent organizational concepts. If the space amount for pathology is changed, for example, the effect is reflected in all sets which contain it. This data mode furnishes information for subsequent programs. Of course the generating routines are encouraged to take small liberties with even such "incontestable" data as gross square feet.

SPACE mode is an environment for the development of diagrams of positional relationships. A command session with this mode resembles two people arguing about a subject neither knows much about. The designer draws upon the machine primarily as an extension of himself for the purpose of talking to himself. In turn, the machine applies these selective bits of information (at first very few) to the making of a complete diagram. The completeness is achieved through substituting missing information with probabilities: unmentioned or unaffected relationships are treated altogether "randomly", whereas partially described relationships are handled with "biased" random numbers.

A session with SPACE mode results in: 1) a better understanding of the criteria by designer; 2) the creation or modification of an internal matrix of probabilities for proximity.

This internal matrix is not symmetrical. The asymmetry stems from the order in which elements are chosen. Initially, the matrix contains probabilities which delineate graded levels of proximity, disparity, and indifference (and is indeed symmetrical). Following the choice of a departure point ("let's handle "Dermatology first") the symmetry is destroyed because subsequent selections will be made as a probabilistic function of the history of choices. The effects of this hisotry can be regulated such that the designer can impose a strong interdependance between organizational structures and positional decisions; or such that he de-emphasizes the interrelations.

SPACE entertains such commands as "reinforce --------", "disperse ------", and statements about nucleation. The machine can respond either graphically (on an $8000 graphics terminal) or alphanumerically (via a teletype-like terminal). The designer's role as critic forces him to exhibit happiness or disappointment about local qualities, mediocrities, or absurdities. His expressions of approval about the positional relationship of, for example, dermatology and cardiology implicitly reinforce that their proximity will reoccur; whereas his disapproval diminishes that likelihood. In another context, however, the same proximity might result in an inappropriate configuration, and thus it is punished. The machine copes with this apparent contradiction by responding to "probabilistic disturbances" caused among other elements related to dermatology and cardiology, and by holding the actual dermatology/cardiology relationship in abeyance.

There are supplementary commands which cause a total dispersion versus concentration of functions and likeness versus variation of schemes. However, notice that all the inputs and outputs of this mode are relative: no mention of absolute positions or orientations. This is done in SITE mode.

SITE mode offers the ability to describe a particular three dimensional region in space into which elements can be placed (following a prespecified module). It allows the description of circulation flows, site orientation, zoning ordinances, and geographic features. Once again we treat these properties on a probabilistic basis, leaving minute chances that the design can exceed the size of the site, violate zoning, or engulf a highway. At present, this mode is only superficially implemented and its inputs to the generating system have not been as influential as the characteristics of site usually are.

ENVELOPE mode is a combination of SPACE and SITE modes. It represents a quasi-resultant of these two forces, inside and outside, which have been separately developed. This mode is the interface between probabilities of relative proximities and of absolute relationships, two often contradictory sets of constraints. When two specific probabilities contradict each other, their resolution only can be handled in this particular mode. A suggested move or criticism by the designer, however, does cause SPACE data and SITE data to change, but most importantly it contributes to a new three dimensional distribution of probabilities representing the external configuration and internal allocation of spaces.

The future of this sort of research resides in the ability to transpose such efforts to an operational system that can handle a considerable number of functions at a reasonable cost. Certain improvements and changes are necessary.

One change is in degree of machine predisposition to a design attitude. A way to avoid prejudice and to insure good solutions is indeed for the machine to generate all possible alternatives, assuming no initial commitment. The probabilistic approach we have chosen avoids such exhaustive searching, converges towards a good solution, but risks missing a still better solution. Hence, some initial bias of process is desirable (at the caution of not imbedding preconceptions of product). One approach is initially to have the designer offer heuristics that can be overridden and rules that get replaced.

Another necessary improvement is to permit local reconfiguring of uses within a scheme without a drastic repercussion in the total composition. At present, each proposal by the machine is a completely new solution that is reconstructed from scratch, reassembling all the parts each time. The present hospital deals with only 240 functions, which makes this approach manageable. However, following the same methods, a neighborhood of one square mile with 60,000 elements would require four millenia of computation to generate one solution. The problem is one of subtly partitioning the elements of a design into local and global parts. The issues which are purely localizable should be handled within a small perimeter of special influences, while the more global characteristics should disperse large influences over many spacially separate elements.

These two definite next steps could make this set of programs into an applicable mechanism where the mentors of the system could be many different kinds of people. We envisage a day when terminals are available to all participants in the hospital design (even children). It is not completely fanciful, because the programs are constructable, the telecommunications exist, and the present cost is less than $20.00 per hour at the terminal.

FOSPLAN: A FORMAL SPACE PLANNING LANGUAGE*

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Abstract

FOSPLAN is a formal space planning language. It has been implemented as a batch processing system on the IBM 360/67, and runs through TSS (Time Sharing System). A HP7200A plotter is also connected to the system for graphic output.

As a piece of research, it falls in the area of automated space planning. Most of the existing systems work as package programs and provide limited programming flexibility to the user. FOSPLAN, being a language, allows the user to do his own programming in solving a space planning problem.

It is based on the theory of formal languages which has been extended to become applicable for two-dimensional configurations. The extensions made are (i) the specifications by which an object (defined as a rectangle representing a three dimensional empty or solid space) can be defined in a singular or iterative manner, and (ii) the composition operation by which objects can be joined in two-dimensional configurations.

Section 3 discusses the syntax, the simulated compiler, the executor and the available search features of the current implementation. It also includes two examples of running programs.

1. Introduction

In recent years, automated and computer-aided space planning have consumed a considerable amount of research activity. FOSPLAN is a formal space planning oriented language that aims to contribute in this area of research.

At least five systems, more or less complete, have been so far published [5, 7, 9, 10, 11]. All of them incorporate some sort of a linguistic structure but their main common characteristic is that they work as package programs. This makes them easy to use but inflexible as programming systems. With the exception of GSP, a user cannot write his own program but can only call the predefined subprogram. In GSP, which has been designed as an extension of Fortran IV, the user can do his own programming. The question here becomes whether or not space planning problems can efficiently be expressed in Fortran. The other systems allow some flexibility by letting the user define a set of parameters in calling the available subprograms and by letting him choose the sequence in which the subprograms are called. Both facilities are at best provided by interactive systems, which IMAGE, URBAN5 and GSP are.

An interactive system is capable of accepting instructions one at a time; thus the user does not need to write a whole program in advance. This facilitates interaction with the computer and is therefore desirable. The point is that the ease provided by the interactive systems makes us too often go around a problem instead of solving it. As Eastman puts it, "while it is straight-forward to use such systems in an interactive design mode, the benefit and challenge of such programs comes from their potential for automated space planning. . ." [6].

The FOSPLAN system has been designed as a language. As such it allows the user, now to some extent and more so after it has been completely implemented, to write his own programs. The system simply compiles and executes those programs; the problems are primarily solved by the programmer and the system only assists that problem solving. Currently, it runs on the IBM 360/67 Time Sharing System (TSS) as a batch processing system. It will only take minor changes to make it interactive; at first though, we want to experiment with and explore its potentialities.

FOSPLAN is based on the theory on formal languages and grammars which was originated by N. Chomsky around 1956 [1, 2]. Since then, a considerable amount of activity has taken place which sufficiently integrated the theory and related it to automata. A fairly complete presentation of this theory can be found in [8]. The 'linguistic approach' has also been extended to that area of the artificial intelligence research that deals with picture interpretation and pattern recognition. Review of such research can be found in [3, 4]. A common characteristic of the suggested linguistic structures is that, in each case, they have been dictated by the nature of the problems to be dealt with. By the same token, the structure implemented in FOSPLAN has been formulated with the space planning problems in mind. It relies heavily on the general theory on transformational grammars, most of which is readily applicable. The extensions introduced make it possible to view the strings as two-dimensional configurations and the words as objects

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In this paper, section 2 presents some basic theory on the formal space planning languages and grammars. Only that part of the theory that has been used in the FOSPLAN implementation is given. For a more complete presentation see [12]. Section 3 describes the syntax and the FOSPLAN Compiler and Executor. It also contains two examples of running programs with their outputs and some discussion on the system's search strategies and the extensions to be made.

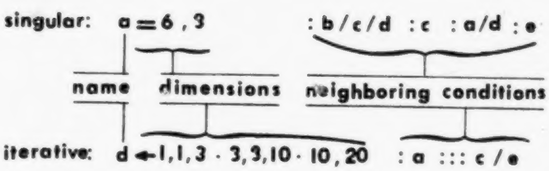
2. Formal Space Languages

2.1 The Objects and Their Specifications

A solid or empty space representable by a rectangular orthographic projection will be called an object. The term initially refers to both the three dimensional space and its two-dimensional representation. In this paper we shall only need to refer it to the representation. Thus an object is a rectangle.

An object will be defined and represented by the use of specifications which are of two kinds: singular and iterative. A specification is a string of characters and consists of three parts, namely the name, the dimensions and the neighboring conditions. First, I will define the syntax of these parts, then their meaning; first for the singular, then the iterative specification. The name is a lower or upper case English letter with or without subscript. For distinction, in typing, a name is underlined, in printing, it is a bold face letter. The names identify the objects. The dimensions, in the singular specification, is an equal sign (=) followed by two numbers separated by a comma. In the iterative specifications, the dimensions, is a left pointing arrow (←) followed by three fields: the first two fields are three numbers separated by commas and followed by a period; the third field is two numbers separated by a comma. The neighboring conditions are four--each is a colon (:) followed by a list of names separated by a slash (/). We use the slashes to indicate alternative neighbors. In the theory, there are no restrictions with respect to the number of potential neighbors each side can accept. Such restrictions do exist in the implementation. The symbol ∅ will be used to indicate that a side accepts no neighbor and the symbol ∀ to indicate that a side accepts any neighbor.

Examples will be


singular: a = 6 , 3 : b/c/d : c : a/d : e
name
dimensions
neighboring conditions
iterative: d ← 1,1,3 · 3,3,10 · 10,20 : a : : : c/e

By the singular specification in the above example, the object a is defined to be a 6*3 rectangle, the first side of which accepts objects b, c and/or d as neighbors, the second side object c, the third side a and/or d and the fourth object e. The geometric representation of object a is shown in Fig.2.1.1. By

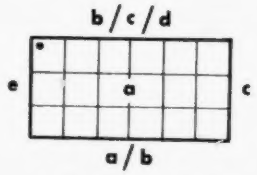


Figure 2.1.1

definition, the first number of the dimensions part refers to the horizontal and the second to the vertical dimensions of the object (Fig.2.1.2). We also define the upper left point of the object as the origin and the sides are indexed by moving clockwise (Fig. 2.1.3). The neighboring conditions correspond to that indexing. We

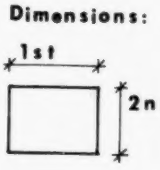


Figure 2.1.2

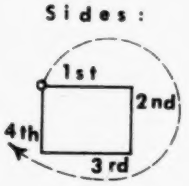


Figure 2.1.3

shall be denoting the location of the origin by a period in the respective corner, as we did in Fig. 2.1.1.

By the iterative specification, the object d is defined as a set of three alternating forms, as shown in Fig.2.1.4. The first field in the dimensions part of the iterative specifications defines an iteration for the horizontal dimen-

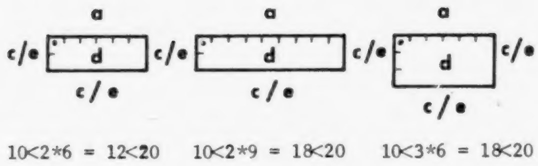


Figure 2.1.4

sion; in our example, from 1, by increments of 1 to 3. Similarly, the second field defines iteratively the vertical dimension. The third field defines an upper and a lower limit for the object's area; in our example d cannot be less than 10 and greater than 20 sq. units. Thus by an iterative specification the dimensions of the object are defined iteratively and then constraints are imposed with respect to the overall area. The object is defined by the rectangles that pass both conditions. How the three variations of d were derived is shown in Fig. 2.1.5.

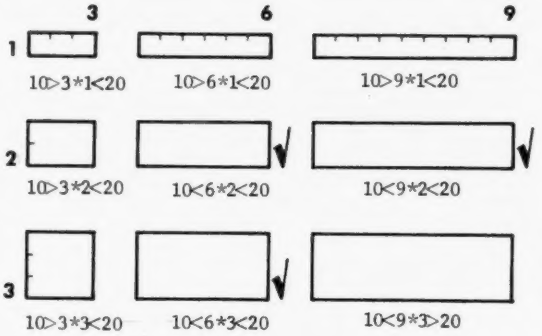


Figure 2.1.5

Semantically, the distinction between a singular and an iterative specification is that the first defines an object uniquely, while the second defines it as a set of variations. An iterative specification may derive an empty set of variations, in which case it is called empty. When the whole set of rectangles, given by the iterations of the sides, is acceptable by the area constraints, the iterative specification is called full. If, in our example, the area limits had been given as 30, 35 or 28, 28 the specification would have been empty; if they were given as 3, 27 the specification would have been full.

Notice that for the neighboring conditions in the iterative specification of our example, we have used a condensed notation. The notation :a:::c/e should be understood as :a:c/e:c/e:c/e. That is, whenever more than one consecutive sides accept identical neighbors, then we can write the neighbors only once by prefixing them with as many colons as consecutive sides with identical neighbors. Repetitions are read from left to right.

2.2 The Operations

We can put two or more objects together to derive a new object. We call this operation composition. The reverse, that is breaking an object down into other objects is called decomposition.

An object that consists of itself only is called primitive. An object is called composite when it is not primitive. Notice that the terms primitive and composite are relative. The primitive objects are given by definition and what is primitive in one case may not be defined as such in another.

We may compose objects in a variety of ways; that is we have different kinds of compositions. One restriction is imposed by our definition of the object. The resulting composite object must be a rectangle. Thus from the configurations given in Fig. 2.2.1, (1) is not an object.

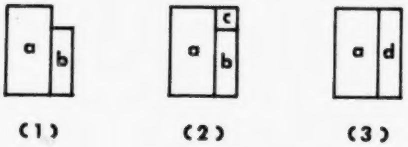


Figure 2.2.1

Junction is the binary composition by which two objects are joined in such a way that a side of the one becomes tangent with a side of the other. Graphically, the two sides coincide. Since the resulting composite should be a rectangle, the sides that coincide should be of equal dimension. The junction will be denoted by ⊕. Thus the composition in Fig.2.2.1(3) is written as a⊕d (where a=2,4:x:d/b/c::x and d=1, 4:::x:a) and was derived by the application of a single junction. The composite in Fig. 2.2.1(2) was derived by the application of two junctions, a⊕(b⊕c) (where a as before, b=1,3:c::x:a, and c=1,1::x:b:a).

It can be proved that any composite object can be expressed as a sequence of junctions (for the proof see [12]). Therefore, we call the junction the basic composition and all the other compositions will be defined as multiple junctions.

As an illustration we shall define the inclosure denoted by → (and ← its converse; that is

$<$ such that $\underline{a} > \underline{b}=\underline{b} < \underline{a}$). Intuitively, the inclosure consists of one object surrounded by another. For example, $\underline{a} > \underline{b}=\underline{b} < \underline{a}$ derives the composites shown in Fig. 2.2.2. Which one is meant depends on the definition of the inclosure and/or the specifications of the objects.

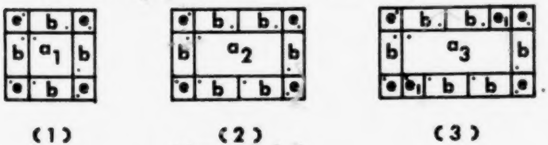


Figure 2.2.2

In case (1) the inclosure accepts a single copy of $\underline{b}$ for each side of $\underline{a}_1$, but only if the neighboring conditions of $\underline{a}_1$ (and $\underline{b}$) so permit. If they do, $\underline{a}_1$ can only be a square. Formally

$$\underline{a}_1 > \underline{b} = \underline{b} < \underline{a}_1 = (\underline{e}\oplus\underline{b}\oplus\underline{e})\oplus(\underline{b}\oplus\underline{a}_1\oplus\underline{b})\oplus(\underline{e}\oplus\underline{b}\oplus\underline{e})$$

where $\underline{a}_1 = k,k$: : : :$\underline{b}$
$\underline{b} = k,h$:$\underline{a}_1$:$\underline{e}$:0 :$\underline{e}$
and $\underline{e} = h,h$: :$\underline{b}$: :0

The name $\underline{e}$ stands for the empty space that by definition supplements the corners of the configuration to make it a rectangle.

In case (2) the inclosure accepts more than one copy of $\underline{b}$ for each side of $\underline{a}_2$ and the perimeter of $\underline{a}_2$ should be completely covered by copies of $\underline{b}$. This implies that the sides of $\underline{a}_2$ should be integer multiples of that side of $\underline{b}$ to be joined with $\underline{a}_2$. Formally

$$\underline{a}_2 > \underline{b}=\underline{b} < \underline{a}_2 = (\underline{e}\oplus\underline{b}(\oplus b)^{m-1}\oplus\underline{e})\oplus((\underline{b}(\oplus\underline{b})^{n-1})$$
$$\oplus\underline{a}_2\oplus(\underline{b}(\oplus\underline{b})^{n-1}))\oplus(\underline{e}\oplus\underline{b}(\oplus\underline{b})^{m-1}\oplus\underline{e})$$

where $\underline{a}_2 = m*k,n*k$: : : :$\underline{b}$(m and n positive integers)
$\underline{b} = k,h$:$\underline{a}_2$:$\underline{e}$/$\underline{b}$:0:$\underline{e}$/$\underline{b}$
and $\underline{e} = h,h$: :$\underline{b}$::0

In case (3) the perimeter of $\underline{a}_3$ needs not to be completely covered by copies of $\underline{b}$. Therefore, the sides of $\underline{a}_3$ should not necessarily be integer multiples of the side of $\underline{b}$ to be joined with $\underline{a}_3$. Formally

$$\underline{a}_3 > \underline{b}=\underline{b} < \underline{a}_3 = (\underline{e}\oplus\underline{b}(\oplus\underline{b})^{m-1}\oplus\underline{e}_1\oplus\underline{e})\oplus(\underline{b}(\oplus\underline{b})^{n-1}\oplus\underline{e}_2)$$
$$\oplus\underline{a}_3\oplus(\underline{b}(\oplus\underline{b})^{n-1}\oplus\underline{e}_2))\oplus(\underline{e}\oplus\underline{b}(\oplus\underline{b})^{m-1}\oplus\underline{e}_1\oplus\underline{e})$$

where $\underline{a}_3 = m*k+p,n*k+q$: : : :$\underline{b}$/$\underline{e}_1$/$\underline{e}_2$
$\underline{b} = k,h$:$\underline{a}_3$:$\underline{e}$/$\underline{b}$:0:$\underline{e}$/$\underline{e}_1$/$\underline{e}_2$/$\underline{b}$
$\underline{e} = h,h$:$\underline{b}$:$\underline{e}_1$/$\underline{e}_2$/$\underline{b}$::0
$\underline{e}_1 = p,h$:$\underline{a}_3$:$\underline{b}$:0 :$\underline{e}$
and $\underline{e}_2 = q,h$:$\underline{a}_3$:$\underline{b}$:0 :$\underline{e}$

Notice that case (1) is contained in case (2) and case (2) is contained in case (3). In case (3) we join each side of $\underline{a}_3$ with as many b's as it can take (m or n) moving clockwise; the remaining portion of the side (p or q) is joined with an empty space ($\underline{e}_1$ or $\underline{e}_2$). We can still define inclosure differently. For example, we can distribute the remaining portions of the sides (p or q) between the copies of $\underline{b}$ on each side, and accordingly locate the supplementary empty spaces.

2.3 The Productions

The expression by which we denote a composition is the production. Syntactically, a production is a name followed by a right pointing arrow followed by one name or two names with a composition operator in between. For example A $\rightarrow \underline{c}\oplus\underline{d}$. It means compose $\underline{c}$ with $\underline{d}$ (by the junction) and call the result $\underline{A}$; it is read as $\underline{A}$ is produced by joining $\underline{c}$ with $\underline{d}$. (We are using upper case letters for names of the composites and lower case for the primitives.) Generally speaking the operands on the right hand side of the production may be either composites or primitives. The derived object (left hand side) can only be a composite. In practical terms, a production defines a replacement operation. Thus $\underline{A} \rightarrow \underline{c}\oplus\underline{d}$ should be understood as replace the $\underline{A}$s found in a given expression by $\underline{c}\oplus\underline{d}$.

We usually want to compose objects at different levels. Those multiple compositions can be represented by a set of productions, such as

$\underline{S} \rightarrow \underline{B} \oplus \underline{c}$
$\underline{B} \rightarrow \underline{A} \oplus \underline{D}$
$\underline{A} \rightarrow \underline{c} \oplus \underline{g}$
$\underline{D} \rightarrow \underline{A} \oplus \underline{A}$

To derive the composite defined by that set of productions, we start with the first production $\underline{S} \rightarrow \underline{B} \oplus \underline{c}$. Then we look at the right hand side and replace all the upper case letters (composites) by the compositions given by the respective productions. In our case, we replace $\underline{B}$ with $\underline{A}\oplus\underline{D}$ (since $\underline{B} \rightarrow \underline{A}\oplus\underline{D}$). We repeat the process till our right hand side contains no more capital letters. The whole process is shown below:

$S \rightarrow \underline{B} \oplus \underline{C}$
$\rightarrow (\underline{A} \oplus \underline{D}) \oplus \underline{c}$
$\rightarrow ((\underline{c} \oplus \underline{g}) \oplus \underline{D}) \oplus \underline{c}$
$\rightarrow ((\underline{c} \oplus \underline{g}) \oplus (\underline{A} \oplus \underline{A})) \oplus \underline{c}$
$\rightarrow ((\underline{c} \oplus \underline{g}) \oplus (\underline{c} \oplus \underline{g}) \oplus \underline{A}) \oplus \underline{c}$
$\rightarrow ((\underline{c} \oplus \underline{g}) \oplus (\underline{c} \oplus \underline{g}) \oplus (\underline{c} \oplus \underline{g}))) \oplus \underline{c}$

We have derived $\underline{S} \rightarrow ((\underline{c}\oplus\underline{g})\oplus(\underline{c}\oplus\underline{g})\oplus(\underline{c}\oplus\underline{g})))\oplus\underline{c}$. In this case we have derived a single composite. But this need not be always the case. We make no restrictions with respect to the number of productions having the same name on their left hand sides. Thus, in our example set of productions, we could have also included the production $\underline{B} \rightarrow \underline{D}\oplus\underline{a}$, deriving $\underline{S} \rightarrow \{((\underline{c}\oplus\underline{g})\oplus((\underline{c}\oplus\underline{g})\oplus(\underline{c}\oplus\underline{g})))\oplus\underline{c}, (((\underline{c}\oplus\underline{g}) \oplus (\underline{c}\oplus\underline{g}))\oplus\underline{a})\oplus\underline{c}\}$

The production to be applied first should be designated; it is called the start production. The name on the left hand side of the start production, usually denoted by $\underline{S}$, is called the start symbol. We may only have one start symbol, but more than one start production is allowed.

2.4 Languages and Grammars

We call the names of the primitive objects terminals and the names of the composites variables.

Then an *alphabet* W is a finite set of symbols that consists of three subsets: the set of terminals T, the set of variables V, and the set of operators Q.

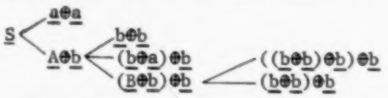
A *word* over an alphabet is a string composed of elements in the alphabet, in such a way that between any two variables and/or terminals there is an operator. A word that contains no variables is called a *terminal word*. Otherwise it is called *sentential*. For example, given $W=\{\underline{A},\underline{b},\underline{c},\oplus\}$ (where $\underline{A}$ is a variable, $\underline{b}$ and $\underline{c}$ terminals and $\oplus$ an operator), the strings $\underline{A} \oplus \underline{b} \oplus \underline{b}$ and $\underline{c} \oplus \underline{c}$ are words over W. The first is sentential and the second is terminal.

We may denote the set of all terminal words over an alphabet W, by U. U is countably infinite. By defining restrictions with respect to the ways by which the elements in W can be composed, we reduce the size of the set U. By doing that we define a language L over W; that is a *language* L over a given alphabet W, is a well defined subset of U. L may be infinite or finite. If finite, we can represent it by simply listing its members (terminal words). The list may be very large or infinite. Therefore more general representations are needed. As such we use the *grammars* and the *recognizers*. A recognizer is an algorithm that, given a word, can tell us if it belongs to a specified language; they will not concern us in this paper. A grammar is an algorithm that sequentially generates the words of a language.

A grammar consists of a set of variables V, a member of which is designated as the *start* variable $\underline{S}$, a set of terminals T, a set of operators Q, and a set of production P which define the rules by which the members of T, V, and Q can be composed. A grammar is denoted as $G = (V,T,Q,P,\underline{S})$, where V, T, Q, P, and $\underline{S}$ are also defined. Example will be

$$G_o=(V,T,Q,P,\underline{S}) \text{ where } \begin{aligned} V &= \{\underline{S},\underline{A}\}, \\ T &= \{\underline{a},\underline{b},\underline{c}\}, \\ Q &= \{\oplus\}, \\ \text{and} \quad P &= \{\underline{S}\rightarrow\underline{A}\oplus\underline{b}, \\ & \quad \underline{S}\rightarrow\underline{a}\oplus\underline{a}, \\ & \quad \underline{A}\rightarrow\underline{b}\oplus\underline{a}, \\ & \quad A\rightarrow B\oplus b, \\ & \quad \underline{B}\rightarrow\underline{b}\oplus\underline{b}, \\ & \quad \underline{B}\rightarrow\underline{b} \ \} \end{aligned}$$

We denote the language generated by a grammar G as L(G). Given G_o as above, we have $L(G_o) = \{\underline{a}\oplus\underline{a},\underline{b}\oplus\underline{b},\underline{b}\oplus\underline{a}\oplus\underline{b},\underline{b}\oplus\underline{b}\oplus\underline{b}\oplus\underline{b},\underline{b}\oplus\underline{b}\oplus\underline{b}\}$. We derived $L(G_o)$ by the use of what is called the *generation* (or *production*) *tree*, which is as follows:



$\underline{S}$
$\underline{a}\oplus\underline{a}$
$\underline{A}\oplus\underline{b}$
$\underline{b}\oplus\underline{b}$
$(\underline{b}\oplus\underline{a})\oplus\underline{b}$
$(\underline{B}\oplus\underline{b})\oplus\underline{b}$
$((\underline{b}\oplus\underline{b})\oplus\underline{b})\oplus\underline{b}$
$(\underline{b}\oplus\underline{b})\oplus\underline{b}$

Notice that in deriving $L(G_o)$ we have used parentheses (as we also did in section 2.3). When we listed its members we left the parentheses out. If we make the rule that the words of $L(G_o)$ are read from left to right, no ambiguity arises. That is $((\underline{b}\oplus\underline{b})\oplus\underline{b})\oplus\underline{b}\equiv\underline{b}\oplus\underline{b}\oplus\underline{b}\oplus\underline{b}$. This is not in general true. It is true here because the productions of G_o satisfy the following condition:

> There are at most two operands on the right hand side, and the second operand, when it exists, is always a terminal.

When this is the case we call the grammar *regular*. When the above condition is relaxed the grammar is called *irregular*. There are three types of irregular grammars but these will not concern us in this paper (see [12]).

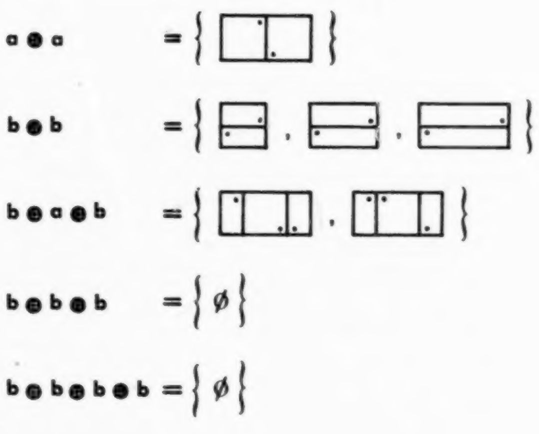
The productions of G_o satisfy one more condition; they are not circular. A set of productions is called *circular* when in the generation tree the same variable appears more than once in the same derivation path. The language generated by a grammar with a circular set of productions is infinite.

2.5. The Specified Language

The grammar G_o, as given in the previous section, generates a language which is not specified. A language is *specified* when its words are given as two-dimensional objects. We denote the specified language of G_o as $L_s(G_o)$. For $L_s(G_o)$ to be derivable, G_o should be supplemented with a set of relevant specifications. By relevant it is meant that the specifications should refer to the terminals contained in the words of $L(G_o)$ and that only those are necessary. Say that G_o is supplemented with the set of specifications

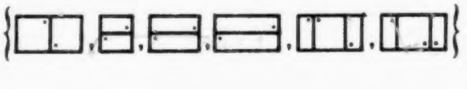
$$R = \{\underline{a}{=}2,2:\underline{a}:\underline{b}:\emptyset:\underline{b},\ \underline{b}{\leftarrow}1,1,\bar{1}.\bar{2},1,\bar{4}.2,4:\underline{a}/\underline{b}:::\emptyset\}$$

It is now denoted as $G_o = (V,T,Q,P,R,\underline{S})$. With R at hand, the terminals in the words of $L(G_o)$ can be specified and the indicated compositions can be executed, as follows:



The specification of $\underline{a}\oplus\underline{a}$ is straightforward; $\underline{b}\oplus\underline{b}$ results into three composites corresponding to the three variations given by the iterative specification for *b*; $\underline{b}\oplus\underline{a}\oplus\underline{b}$ results into two composites that differ only by the location of the origin of *a*; finally $\underline{b}\oplus\underline{b}\oplus\underline{b}$ and $\underline{b}\oplus\underline{b}\oplus\underline{b}\oplus\underline{b}$ result into empty objects, since, by the neighboring conditions for *b*, only one of its sides can be joined with another object. Thus

$L_s(G_o)=$



3. The FOSPLAN Implementation

3.1 Syntax

FOSPLAN currently incorporates four types of statements; the area statement, the function definition statements, the command statements, and the end statement.

The *area statement* is the sys (system's symbol) AREA, followed by one to ten area declarations separated by commas. An *area declaration* is an area name followed by two numbers enclosed in parentheses and separated by commas. An *area name* is a name. A *name* is a string of up to four alphanumeric characters, the first of which is alphabetic (A-Z). An example will be

```
AREA ALFA(9,6), BETA (8,8)
```

The *function definition* statements are of five types: the function head, the productions, the singular and iterative specifications and the function end statement. The *function head* is the sys FUNCTION followed by a function name, possibly followed by an argument list. The *argument list* is one to ten arguments separated by commas and enclosed in parentheses. The *function names* and the *arguments* are names. An example will be

```
FUNCTION DINA (A,B,MIN,MAX)
```

A *production* is a variable followed by an up pointing arrow (↑), followed by a composition. A special case is the *start production* where the variable is the start variable. The *composition* is a single terminal, or a variable followed by a terminal, or two terminals, with an operator in between. A *terminal*, a *variable*, and a *start variable* are names, the first character of which should be a T for the terminals, a V for the variables and an S for the start variable. An operator is one of the symbols +, >, and <. Examples will be

```
SS ↑ VARC + TT1
VA2↑ T1
V11↑ T3> TAF
```

A *singular specification* is a terminal followed by a singular dimensions part, followed by the neighboring conditions. The *singular dimensions* are an equal sign (=) followed by two parameters separated by a comma. A parameter is a number or a name. The neighboring conditions are four: each is a colon (:) followed by one to three variables and/or terminals. An example will be

```
T2 = 2,A:T1/E1:EE22/T2::E1/EE1/T2.
```

The definition for the iterative specifications as for the singular with iterative dimensions instead of singular. The *iterative dimensions* are a left pointing arrow (←) followed by three fields separated by periods; the first two are three parameters separated by commas; the third is two parameters separated by a comma. An example will be

```
T1←1,1,A. 1,1,B. MIN,MAX : : : :T2.
```

Notice that the condensed way of writing the neighboring conditions has also been implemented. We have been using names starting with an E for system provided empty spaces.

The *function end* statement is the sys END

A *command statement* is the sys TRY, followed by a star (*) followed by the number 1, 2, or 3, followed by a function name followed by a list of one to ten numbers separated by commas and enclosed in parentheses, followed by the sys IN followed by an area name. Examples will be

```
TRY*1 DINA (5,3,8,15) IN ALFA,
TRY*3 LOLA (2,3) IN BETA.
```

The *end statement* is the sys END.

The FOSPLAN statements are format free and can be typed anywhere on a teletype line. If the first character is a star (*), the line is understood to continue the previous one. Blanks can be embedded anywhere (but not between the characters of a name).

A program in FOSPLAN should always start with an area statement. This allocates for each declared area name the space indicated in the parentheses following the names.

The function definitions should come next. Currently, up to ten definitions are accepted. Each should have a function head as its first and a function end as its last statement. Each entry in the argument list should correspond to the non-numeric parameters found in the body of the function definition. Within the body, the start productions should be first, followed by the other productions (if any), followed by the singular specifications (if any) followed by the iterative specifications (if any).

The function definitions are followed by the command statements which call the functions for execution. The command TRY*3 LOLA(2,3) IN BETA means execute the function LOLA (after you replace the respective arguments with 2 and 3) and out of the set of objects generated by it, pick the three that fit at best in the space BETA. The criteria for this selection are currently dimensional only.

The program should close with an end statement. Examples of whole programs written in FOSPLAN are given in section 3.3.

Notice that the current implementation incorporates two built-in compositions, namely the junction (+) and the inclosure (>, <). No facilities for user-defined operations are provided. This is one of the first extensions to be made.

3.2 The FOSPLAN Compiler and Executor

A compiler for FOSPLAN has been simulated in the WATFIV version of Fortran IV, running through the Time Sharing System (TSS), on the IBM 360/67. Connected to the system is a HP 7200A plotter for graphic output. A complete description of the FOSPLAN compiler is given in [13]. A short discussion on its basic structure is also given below.

The compiler consists of two passes. The first is primarily a recognizer which checks the syntax of each FOSPLAN statement and the program as a whole. If errors are found the user is notified accordingly. The first pass also assigns numeric names to the variables and the terminals. The second pass generates and stores internally numberic code to be executed after compilation is complete.

The numeric code is decimal numbers with a preassigned meaning and is stored in three groups of tables, namely the area table (AT), the function tables (FT), and the command tables (TT). The executor, which is again a program in WATFIV, traces the command table sequentially and follows the instructions found there. The decimals stored in TT are interpreted according to their values and locations. TT contains a variety of pointers to both the AT and the FT. Thus the information stored there becomes available to the executor.

For each function called, the productions are executed at first and the unspecified words are derived. In doing that the executor keeps track of the generation tree. Thus for each word derived, the production path can be made available, if the programmer so desires.

After the full set of unspecified words has been derived, each is specified by applying the respective specifications. Each word may be specified as empty or one or more objects, depending on the dimensions and the neighboring conditions in the specifications. The specified objects are checked for fitness in the indicated area and the solution(s) is (are) derived. The output at this point is the graphic two-dimensional representation of the derived objects and is given by the plotter.

3.3 Example FOSPLAN Programs

In this section two examples of running FOSPLAN programs will be given. In the first both the listing of the program as typed on the teletype and the listing of the program as was formated by the FOSPLAN compiler are given. In addition, the second listing is supplemented with the numeric names assigned to the variables and the terminals and the statement recognition numbers as depicted by the compiler.

The listing of the programs are followed by the output which in both cases consists of a listing of the generation tree (under the title GTR,WGE) and a listing of the unspecified words (under the title USW,UWL). The words are given by both their numeric and their initial names. Following the teletype output, the plotter output of the specified words of the solution(s) has been attached.

The first program is for the design of a house floorplan. The command TRY*3 HOUS (5,9) IN ALFA finds the three composites that best fit the indicated space. Notice that designs 1 and 2 completely fill the 10*9 space. The one labeled 1 was picked first because it was generated first. The command TRY*1 HOUS (6,11) IN BETA finds a single solution.

The second program is for the design of a dining kitchen. Because we have limited the FOSPLAN syntax to regular grammars, there is no way to program the dining-kitchen as a whole, but only in parts. This shortcoming suggests that the FOSPLAN syntax should be extended. How the parts relate and their architectural interpretation is shown on the design attached to the plotter output.

Generally speaking, in space planning problems, the function to be resolved has some constant and some variable attributes, with respect to both the dimensions of the individual elements (objects) and their relations. In this sense the given examples are quite realistic. In the first, only one object (T1) has been defined as a constant. In the second, five of the specifications are singular (constant) and three are iterative (variable). Here we also have variable relations, implied by the appearance of SS on the left hand side of three productions. Typically, to solve such problems, we start with the constant characteristics and try to reach values for the variable, such that the given overall dimensional and functional conditions are satisfied. Such a problem solving technique, as implemented in FOSPLAN, is illustrated by the examples.

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FIRST EXAMPLE

I. The program
   a. As the user typed it on the teletype
   b. The system's formated printout.

II. The teletype output
   a. The generation tree
   b. The unspecified language (solution).

III. The plotter output
   a. Response to the first command
   b. Response to the second command

Ia

```
SENTRY
  AREA ALFA (9,10),BETA(10,10)
      FUNCTION HOUS (A,B)
    S↑  V3 + T5
     V3 ↑  V2+T4
    V2↑    V1 + T3
  V1 ↑  T2+T1
  T1 =  3,3:T3:T2::E1
     T2← 3,1,4.2,1,3.6,12 :T1:T3:T4:E1
 T3 ← 2,1,2.4,1,6.10,12 :T5:T4:T2/T1:E1
    T4  ← 4,1,6.3,1,4.12,20 :T2/T3:T5::E1
 T5 ←5,1,A.8,1,B.40,50:T4/T3:::E1
   END
   TRY*3  HOUS (5,9) IN ALFA
   TRY*1 HOUS (6,11) IN BETA
 END
```

b

```
WATFIV FOSPLAN
WATFIV ENTERED 18:02:1796 TUE, 09 NOV 1971


          SENTRY
 1 ( 1, 0) AREA     ALFA(9,10),BETA(10,10)
 2 ( 2, 1) FUNCTION HOUS(A,B)
 3 (20, 1) 100  S   ↑V3+T5
 4 (21, 1) 101  V3  ↑V2+T4
 5 (21, 1) 102  V2  ↑V1+T3
 6 (21, 1) 103  V1  ↑T2+T1
 7 (22, 1) 201  T1  =3,3:T3:T2::E1
 8 (23, 1) 301  T2  ←3,1,4.2,1,3.6,12:T1:T3:T4:E1
 9 (23, 1) 302  T3  ←2,1,2.4,1,6.10,12:T5:T4:T2/T1:E1
10 (23, 1) 303  T4  ←4,1,6.3,1,4.12,20:T2/T3:T5::E1
11 (23, 1) 304  T5  ←5,1,A.8,1,B.40,50:T4/T3:::E1
12 (24, 1) END
13 ( 5, 0) TRY*3    HOUS(5,9)INALFA
14 ( 3, 0) TRY*1    HOUS(6,11)INBETA
15 ( 6, 0) END
```

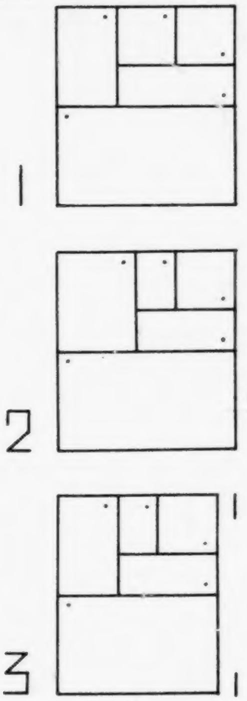
IIa

```
    GTR, WGE
1/     2  0   0   0   0
        0 0    0 0    0 0    0 0 100
2/     3  0   0   0   0
        0 0    0 0    0 0 101  1 304
3/     4  0   0   0   0
        0 0    0 0 102  1 303  1 304
4/     5  0   0   0   0
        0 0 103  1 302  1 303  1 304
5/     0  0   0   0   0
      301 1 201  1 302  1 303  1 304
```

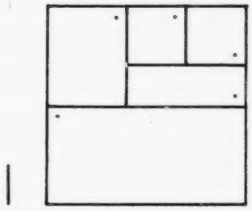
b

```
    USW, UWL
1/    301 1 201  1 302  1 303  1 304
    T2  +T1  +T3   +T4   +T5
```

TRY*3 HOUS(5,9) IN ALFA IIIa



TRY*1 HOUS(6,11) IN BETA b



SECOND EXAMPLE

I. The Program

II. The teletype output
  - a. The generation tree
  - b. The unspecified solution

III. The plotter output
  - a. Response to the first command
  - b. Response to the second command
  - c. Response to the third command

IV. The architectural interpretation

I

```
WATFIV FOSPLAN
WATFIV ENTERED 17:28:2387 TUE, 09 NOV 1971


          $ENTRY
 1 ( 1, 0) AREA      A1(9,6),A2(6,6),A3(15,3)
 2 ( 2, 1) FUNCTION KIDI(A,B,C,D,E,F)
 3 (20, 1) 100  SS  :T1>T2
 4 (20, 1) 100  SS  :T7+T8
 5 (20, 1) 100  SS  :V1+T3
 6 (21, 1) 101  V1  :V2+T6
 7 (21, 1) 102  V2  :T4+T5
 8 (22, 1) 201  T2  =2,3:T1:T8/E1:E1:T2/E1
 9 (22, 1) 202  T7  =3,2:T8:::E1
10 (22, 1) 203  T3  =2,6:::E1:T6
11 (22, 1) 204  T5  =2,3:T4::E1:T6
12 (22, 1) 205  T4  =2,3:T5:T6::E1
13 (23, 1) 301  T1  -3,1,A.4,1,B.10,18:E1:T2:E1:T8
14 (23, 1) 302  T8  -2,1,C.5,1,D.10,55:T7:::E1
15 (23, 1) 303  T6  -2,1,E.4,1,F.10,20:E1:T3:E1:T4/T5
16 (24, 1) END
17 ( 3, 0) TRY*1    KIDI(4,7,4,14,4,8)INA3
18 ( 3, 0) TRY*1    KIDI(4,7,4,14,4,8)INA2
19 ( 3, 0) TRY*1    KIDI(4,7,4,14,4,8)INA1
20 ( 6, 0) END
```

II a

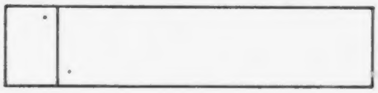
```
      GTR, WGE
 1/    2  3  4  0  0
        0 0   0 0   0 0   0 0 100
 2/    0  0  0  0  0
        0 0   0 0   0 0 301 2 201
 3/    0  0  0  0  0
        0 0   0 0   0 0 202 1 302
 4/    5  0  0  0  0
        0 0   0 0   0 0 101 1 203
 5/    6  0  0  0  0
        0 0   0 0 102 1 303 1 203
 6/    0  0  0  0  0
        0 0 205 1 204 1 303 1 203
```

b

```
      USW, UWL
 1/    301 2 201 0   0 0   0 0   0
      T1  >T2
 2/    202 1 302 0   0 0   0 0   0
      T7  +T8
 3/    205 1 204 1 303 1 203 0   0
      T4  +T5  +T6  +T3
```

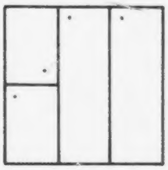
III a

TRY*1 KIDI(4,7,14,4,8) IN A3



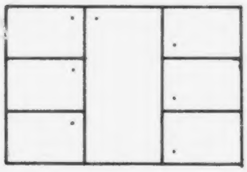
b

TRY*1 KIDI(4,7,14,4,8) IN A2

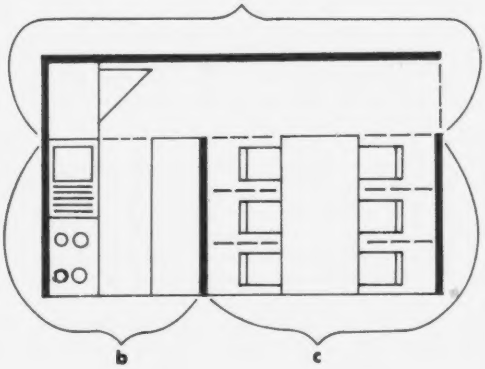


c

TRY*1 KIDI(4,7,14,4,8) IN A1



IV



3.4 Search Features

A space planning problem, typically, seeks to derive a configuration of a given set of objects in such a way that a set of conditions are satisfied. These conditions can be viewed positively as relations or negatively as constraints. In FOSPLAN, they are viewed as relations and become part of the definition of each object. In the other systems the relations and the constraints are implemented as independent entities and are connected with each other by external means.

Having included the necessary conditions in the definition of the object, the derivation of a configuration becomes straightforward. Primitive objects are joined into composites and then composites are joined into higher level composites until a configuration at the highest level is derived. It is different again from the way the other systems derive the solutions. IMAGE generates an initial configuration arbitrarily and then by the application of multiple relational tests, relocates each element till all or as many as possible relations are satisfied. Grason's GRAMPA, Pfeffercorn's DPS and Eastman's GSP, each in a slightly different way, generate for each element to be located next, candidate locations (the whole set or one at a time) and pick the one that satisfies the respective set of relations and/or constraints. For more detailed discussion on those approaches see [6]. In FOSPLAN this is done only with the final configuration at the highest level.

In space planning problems, the exact definition of the object elements, the relations and the constraints that are achieveable can hardly be known right from the beginning. Typically human designers start with an initial set of such definitions which are progressively corrected as problem solving proceeds. The initial definitions may be incomplete or may be contradictory. In the first case the output is more than one (usually a large number of) solutions. Choosing one of the solutions, in actuality means restricting the original definitions. In computer systems we usually work the other way around. We restrict our definitions to reduce the solution space till it becomes of manageable size. In the second case our problem becomes over constrained and the output may be empty. The thing to do here is to start relaxing our definitions until at least one solution is derivable.

Still another approach is to keep the original definitions as they are and start generating solutions which do not satisfy all the conditions. Each is graded according to the degree of fulfillment and the one with the highest score is designated as the final solution.

The above techniques have beem implemented in FOSPLAN. The flexibility offered by the iterative specifications, the possibility of defining alternative neighbors, and the generation process as defined by the set of productions are important features of the system. Unless syntactical errors are depicted, FOSPLAN will always reach at least one solution. That solution may not be satisfactory. In such a case the programmer should redefine his objects. In this he is assisted by the backtracking facilities provided by the system.

3.5 Limitations and Extensions

The two main limitations of the current FOSPLAN implementation have already been pointed out. First, it does not contain facilities for user-defined operations. Secondly, it accepts only regular grammars. Its repertoire will increase remarkably if it is made to accept context sensitive grammars also. Both features are to be included.

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24: DESIGN OF THE BUILDING FABRIC

A NORMALIZATION PROCEDURE IN BUILDING METHODOLOGY

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Abstract

In the design of large electrical, mechanical, structural, etc., systems, the architect frequently faces a normalization problem: given a system made by a large number of components, a procedure, generally a numerical procedure, is available for the determination of the minimum size required by each one of the components. The adoption of the sizes obtained in this fashion would then represent the optimum design solution in the sense of minimum cost if it were not for the well-known fact that repetition of components in a system yields a reduction in fabrication and assemblage costs. If the fractional reduction in cost due to repetition is assumed to be known for each type of component, the problem consists in determining the combination of sizes for which the greatest reduction is achieved. This is a combinatorial problem of vast arithmetic proportions unless a methodological approach is employed. In the present research a method based in the theory of Dynamic Programming has been developed using elements of Graph Theory and Optimization. The model and its solution is presented using as an example of application the problem of normalizing the structural sections of a housing project. Application to other areas of building methodologies are also discussed. A computer program and numerical illustrative results complete the presentation of the model. At present, a stochastic version of the model is being developed.

Introduction

At the "dimensioning" stage of large electrical, mechanical, structural, etc. systems, the architect frequently faces a number of normalization problems. In fact, at this stage the system will be formed by a large number of components whose dimensions have been determined by procedures that in general fail to recognize the true complexity of the system. For example, we possess very powerful methods to optimize the structural elements of a building but these procedures do not in general account for the interaction of the structural topology and the associated cost of fabrication and assemblage, and much less do they account for the interaction of the structure with other systems composing the entire building. The same is true in considering a number of mechanical, electrical, etc., systems. Clearly, the adoption of the optimum sizes obtained with those methods will not in general lead to the optimum design solution of the entire system, because what is optimum with respect to one function will be in general sub-optimal for two or more functions. This is particularly true when we consider operative and manufacture costs in addition to straight forward consideration of cost due to volume of materials. It is in effect known that repetition of components in a large system yields in general a reduction in fabrication and assemblage costs. A meaningful step in the design process is therefore to normalize the dimensions of the elements composing a system in such a way as to achieve a reduction in cost. The present paper is devoted to a methodological treatment of this particular design stage. We shall consider here the simplest version of this problem as an example of a methodological approach that admits considerable generalization in the realm of building methodology. Assuming that the fractional reduction in cost due to repetition of a number of elements is known, the problem now consists in determining the combination of sizes for which the greatest reduction in cost is achieved. This is a combinational problem or vast arithmetic proportions unless a methodological approach is employed. The dynamic programming algorithm of the allocation problem has been previously pointed out as an efficient technique for the solution of problems of this kind in the realm of structural design [1]. In this paper we present a methodological approach for the formulation and the solution of problems of the present type based in elements of Graph Theory and Optimization. This approach has proved to be highly efficient and easy to teach as it is demonstrated by the fact that it is the main theme for an undergraduate interdepartmental course in methodological aspects of design that it is regularly taught by the authors to students of architecture and engineering at the Berkeley Campus.

The model and its solution is presented using as an example of application the problem of normalizing the structural sections of a housing project. A computer program and numerical illustrative results complete the presentation of the model. At present, a stochastic version of the model is being developed.

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The Model

A system containing n components (elements) of the same category is to be designed to perform adequately under various conditions. The definition of adequacy of performance depends on the type of system under consideration. In a building, for example, the relevant components might be all the beams of the same length in the structural frame. The performance of the system would then be its response to various loading conditions and the adequacy of response might be composed of certain requirements on stress and deflection values, yielding of material, or failure of members due to buckling or fatigue. It is assumed that methods of analysis and design relevant to the conditions of adequacy are available to determine the minimum allowable component sizes, i.e., to select a set of n components, each of which is just sufficient to satisfy all conditions of adequate performance. This set of components represents a design for the system. In many systems of interest, adequacy of performance is an increasing function of the amount of material used, in efficient system components. Thus, if there exists a finite, discrete set of m available component sizes (and thus m different levels of performance) from which to choose, the selected set of minimum allowable performance components for the system can be expressed as

n_j components of size j, $j=1,2,\ldots,m$ (1)

with

$$\sum_{j=1}^{m} n_j = n, \text{ the total number of components in the system} \qquad (2)$$

and this design is the minimum weight design due to the relationship between performance and amount of material.

For some classes of systems (e. g., structures such as airplanes and spacecraft) weight is the predominant factor in determining the ultimate total cost of constructing and using the system, and thus the minimum-weight design is also effectively the minimum-cost design. However, in many other systems the fabrication costs are equal or even dominant factors with the material and weight-penalty costs. Fabrication costs per component can often be reduced through normalization of components, i.e., the manufacture of many identical components, but the material costs increase because some components in the system are then larger or heavier than necessary for adequate performance. The problem is thus a smoothing problem of selecting the set of components that minimizes the total cost by balancing these two competing effects.

If the m different component sizes are arranged in order of decreasing size or weight, then we define

c_j = the cost of one component of size j, assuming only one is fabricated ($J=1,2,\ldots,m$) (3)

and

$r_j(i)$ = overall fractional cost reduction factor for size j if i components of that size are fabricated together. (4)

Then the total cost of k_j components of size j is given by

$$a(k_j,j) = k_j c_j [1 - r_j(k_j)] \qquad (5)$$

and the total cost of the system is

$$A = \sum_{j=1}^{m} a(k_j,j) \qquad (6)$$

An artificial stratification of the selection problem is possible because of the separable form (6) of the total cost function.

The optimization problem of minimizing cost may then be viewed as an m-stage sequential component selection process, with constraints on the selection (decision) imposed by the requirements of adequate system performance. These constraints are given by the previously determined minimum-performance design (1), (2):

at least n_1 components of size 1 (the largest)

at least n_2 components of size 2 or larger

at least n_3 components of size 3 or larger

$\vdots$ (7)

at least n_m components of size m or larger

If the selection begins with the largest size component, these constraints become

$$\text{at stage (size) j, } N_j = \sum_{i=1}^{j} k_j \geq \sum_{i=1}^{j} n_j \qquad (8)$$

where k_j is the number of components chosen to be of size j.

The Methodology

In many types of discrete-state, multistage decision processes, a map or graph is useful in illustrating the process and visualizing its solution procedure. If the horizontal axis of the graph represents successive component sizes and the vertical axis represents cumulative number of components (N_j) chosen up to and including size (stage) j, then the graph of possible combinations of selected elements appears as in Figure 1. A possible combination of selected elements (a sequence of decisions or policy) is represented by a path from point (0,0) to point (n,m). All possible paths are bounded by two limiting system designs:

1) the fully-normalized or uniform-component design (upper bound)

2) the minimum component performance or minimum-weight design (lower bound).

In terms of coordinates on the graph, for example, the paths representing these two designs can be written as

UNIFORM COMPONENT: $(0,0)\to(n,1)\to(n,2)\to\dots\to(n,m)$

MINIMUM COMPONENT: $(0,0)\to(n_1,1)\to(n_1+n_2,2)\to\dots\to(n,m)$

(9)

Exhaustive enumeration of all allowable paths in the graph (Figure 1) would be one way of computing the costs of different system designs and finding, by direct search, the lowest resulting cost. However, the number of allowable paths is of the order of $(\frac{n}{2})^m$, which makes direct enumeration computationally impossible for large systems.

An approach to multistage analysis called dynamic programming [2] is ideally suited for this class of problems because it exploits the separable nature of the cost function (equation 6) to obtain an efficient recursive solution procedure. The dynamic programming approach, which renders much larger problems computationally solvable than does a direct enumeration approach, will be explained in the following section.

The Dynamic Programming Solution

Following the ideas of discrete dynamic programming [2], we define

$f_j(N_j)$ = the minimum cost after selection of N_j total components from among j successive sizes. (10)

Then the principle of optimality of dynamic programming (page 15 of [2]) provides the key to obtaining the recursion relations needed to solve this problem. From equation (6), equation (10) becomes

$$f_j(N_j) = \underset{k_1,k_2,\dots,k_j}{\text{minimum}} \sum_{i=1}^{j} a(k_i,i) \qquad (11)$$

Proceeding formally with equation (11), we may separate the minimum operation to obtain

$$f_j(N_j) = \min_{k_j}\left[\underset{k_1,k_2,\dots,k_{j-1}}{\text{minimum}} \sum_{i=1}^{j} a(k_i,i)\right] \qquad (12)$$

Then (12) becomes, by separation of the summation terms,

$$f_j(N_j) = \min_{k_j}\left[a(k_j,j) + \underset{k_1,k_2,\dots,k_{j-1}}{\text{minimum}} \left\{\sum_{i=1}^{j-1} a(k_i,i)\right\}\right] \qquad (13)$$

From the definition (10) and equation (11), we finally obtain

$$f_j(N_j) = \min_{k_j}\left[a(k_j,j) + f_{j-1}(N_j-k_j)\right] \qquad (14)$$

Upon substitution of (5) and consideration of the constraints (7), (14) can finally be written as a set of functional recurrence relations

$$f_j(N_j) = \underset{0\le k_j\le L_j}{\text{minimum}}\left[k_jc_j\{1-r_j(k_j)\} + f_{j-1}(N_j-k_j)\right] \qquad (15)$$
$$(j=2,3,\dots,m)$$

where

$$L_j = N_j - \sum_{i=1}^{j-1} n_i, \quad \left(\sum_{i=1}^{j} n_i \le N_j \le n\right) \qquad (16)$$

and

$$f_1(N_1) = N_1c_1[1-r_1(N_1)] \text{ (initial condition)} \qquad (17)$$

The equations (15), (16), and (17) are then solved successively for each value of j, and at each value of j for each possible value of N_j, up to the end-point $f_m(n)$, which is then the minimum cost of the total system. The selected optimal policy (optimal sequence) of component sizes is then determined by a trace-back through the sets of values $k_j^*(N_j)$ which satisfied the minima in equation (15) at each stage j and each level N_j. In the following section, a FORTRAN subroutine computer program is developed to perform the dynamic programming solution (15)-(17).

The Computer Program

The digital computer solution of the above general component selection problem may be accomplished by a FORTRAN subroutine. Define the following FORTRAN variables:

Data variables -

NBT = number of components in the total system (n)

NT = number of different component sizes available (m)

Data arrays (dimensions) -

COSTF(NT) - cost of one component of each size, if only one is fabricated (c_j)

CRED(NBT) = overall cost reduction factors for multiple-component fabrication (r(i))

NBMIN(NT) = number of components of each type in the minimum weight design (n_j)

Computation and storage arrays (dimensions) -

F(NBT,2) = current stage (col. 2) and previous stage (col. 1) minimum cost values $(f_j(N_j))$

IPOL(NBT,NT) = selection policy values $(k_j^*(N_j))$

Result or solution array (dimension) -

NBOPT(NT) = number of components of each size selected to minimize the total cost of the structure

The minimum cost of the system is located in F(NBT,1) at the end of execution of the subroutine. A complete FORTRAN listing of subroutine MCESDP (for minimum cost element selection by dynamic programming) appears in Figure 2.

An Example Problem

Consider a three-story, multi-bay building frame containing 15 beams of the same length dimension. The structure is to be constructed from precast, prestressed concrete members. Some method of hand calculations or a computer analysis, e.g. SAP (Structural Analysis Program) has been used to determine the minimum-weight design. This design, consisting of five different beam cross-section sizes, is given in Table 1.

Costs for each size of member, assuming only one member of that size is being fabricated, are also given in Table 1. The information supplied by the concrete beam manufacturers concerning the cost reduction factors for multiple-beam fabrication is given in Table 2.

The solution of this problem is straightforward. Subroutine MCESDP, coupled with a main program for Input/Output, finds the minimum-cost design in .014 seconds of CDC-6400 central processor time (Table 3). The output of the main program includes Tables 1, 2, and 3.

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```
***************************************************
DYNAMIC PROGRAMMING SELECTION OF  15 STRUCTURAL
ELEMENTS FROM AMONG  5 TYPES, FOR MINIMUM COST.
***************************************************

            ELEMENT TYPE DATA   (TABLE 1)

-----------------------------------------
ELEMENT   COST FOR   NUMBER OF ELEMENTS
 TYPE   ONE ELEMENT  IN MIN. WT. DESIGN
-----------------------------------------
   1       110.50           3
   2        90.00           1
   3        88.50           8
   4        65.00           1
   5        50.00           2
-----------------------------------------


         COST REDUCTION FACTORS   (TABLE 2)

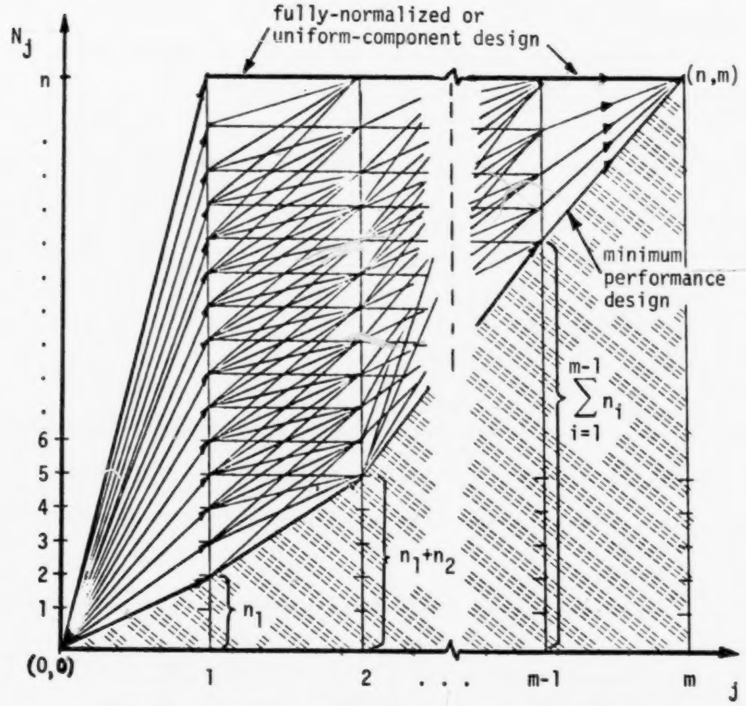
-----------------------------------------
NUMBER OF SIMILAR    OVERALL COST
  ELEMENTS USED    REDUCTION FACTOR
-----------------------------------------
        1               .
        2              .070
        3              .110
        4              .140
        5              .140
        6              .140
        7              .140
        8              .140
        9              .140
       10              .140
       11              .140
       12              .140
       13              .140
       14              .140
       15              .140
-----------------------------------------
```

```
      MINIMUM COST SELECTION TABLE

--------------------------------------------
ELEMENT       NUMBER OF              COST
 TYPE         ELEMENTS          (IN DOLLARS)
--------------------------------------------
   1              3                 295.03
   2              4                 309.60
   3              5                 380.55
   4              1                  65.00
   5              2                  93.00
                ---               --------
TOTAL ELEMENTS= 15  TOTAL COST= 1143.18 DOLLARS


SELECTION TOOK   .014 SECONDS OF
CDC-6400 CENTRAL PROCESSOR TIME
```

TABLE 3


fully-normalized or
uniform-component design
N_j
n
(n,m)
6
5
4
3
2
1
(0,0)
1
2
. . .
m-1
m
j
minimum
performance
design
$\sum_{i=1}^{m-1} n_i$
n_1+n_2
n_1

STAGES = component sizes (in decreasing order)

(shaded portion of graph violates adequate-performance)

FIGURE 1 DIRECTED GRAPH OF POSSIBLE COMPONENT SELECTION COMBINATIONS IN THE DYNAMIC PROGRAMMING APPROACH

```
      SUBROUTINE MCESDP(NT,NBT,COSTF,NBMIN,CRED,NBOPT,F,IPOL)
C***********************************************************************
C
C   SUBROUTINE FOR THE MINIMUM-COST SELECTION OF COMPONENTS OF A SYSTEM
C   BY DYNAMIC PROGRAMMING
C
C***********************************************************************
      DIMENSION COSTF(NT),NBMIN(NT),CRED(NBT),NBOPT(NT),F(NBT,2),IPOL(NB
     1T,NT)
C***********************************************************************
C
C   FIRST STAGE (SIZE)
C
C***********************************************************************
      II=NBMIN(1)
      DO 1 I=II,NBT
      IPOL(I,1)=I
    1 F(I,1)=I*COSTF(1)*(1.-CRED(I))
C***********************************************************************
C
C   LOOP FOR REMAINING STAGES (2 THROUGH NT)
C
C***********************************************************************
      DO 2 J=2,NT
      IPR=II
      II=II+NBMIN(J)
C***********************************************************************
C
C   LOOP FOR ALL ALLOWABLE N(J) VALUES (LEVELS)
C
C***********************************************************************
      DO 3 I=II,NBT
      FMIN=F(I,1)
      IPOL(I,J)=0
      KMAX=I-IPR
C***********************************************************************
C
C   LOOP FOR PERFORMING MINIMIZATION AT EACH POINT IN THE GRAPH (I,J)
C
C***********************************************************************
      DO 4 K=1,KMAX
      TEST=F(I-K,1)+K*COSTF(J)*(1.-CRED(K))
      IF(TEST.GT.FMIN)  GO TO 4
      FMIN=TEST
      IPOL(I,J)=K
    4 CONTINUE
    3 F(I,2)=FMIN
C***********************************************************************
C
C   SHIFT VALUES OF MINIMUM-COST FUNCTION TO PREVIOUS COLUMN
C
C***********************************************************************
      DO 6 I=II,NBT
    6 F(I,1)=F(I,2)
    2 CONTINUE
C***********************************************************************
C
C   TRACE-BACK THROUGH POLICY ARRAY TO OBTAIN NUMBER
C   OF COMPONENTS OF EACH TYPE SELECTED
C
C***********************************************************************
      DO 5 J=1,NT
      NBOPT(NT+1-J)=IPOL(II,NT+1-J)
    5 II=II-NBOPT(NT+1-J)
      RETURN
      END
C
C***********************************************************************
```

FIGURE 2

HOMELAB: INTEGRATION OF NEW CONCEPTS FOR THE LIVING UNIT

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Introduction

During the last few years, Westinghouse has made a considerable expansion in the fields of construction. New subsidiaries such as Urban Systems Development Corp. of Arlington have been formed and acquisitions of established firms within the building industry have been made, such as C. W. Blakeslee & Sons of New Haven, which is a producer of the Bison concrete building system in the U.S.A.

Our Research Laboratories in Pittsburgh not only have the duty of helping to solve technical problems as they may occur within our operating divisions, but also try and develop new concepts and ideas which will be of help to the divisions in the future. Thus, as with the overall position of Westinghouse as it relates to the construction industry, there has been considerable expansion of this type of activity within our Research Laboratories.

We have many programs underway which relate to the construction industry and the home. More obvious programs, such as air conditioning and cleaning, lighting, cooking, etc., have been joined by programs dealing with water purification, sewage, waste disposal, electrical distribution, new plastics and special building materials as they concern the home environment.

Like many large research organizations, we have the tendency to segregate projects within their own laboratories or development areas. It takes both effort and time to find out what the other fellow is doing on an adjacent program, and to keep up with each other's progress. The concept of HOMELAB was an effort on our part to correct this situation. In short, the idea was to bring together within the Research Center, at one place, many of the ideas, system concepts and hardware which form the home, so that we can not only evaluate each project upon its own merits but also see how such a project will integrate into the overall complexity of a house. Not only this, but we were interested in seeing how a new product idea would blend into the aesthetics of a home and satisfy the homeowner.

Our first consideration was to obtain a house. The choice was considerable, but at the back of our minds we felt that we would like something a little different from what could be bought or built on the local scene. During the summer of 1970, I had visited various countries in order to evaluate their progress upon prefabricated homes. I had been particularly struck by what I had seen in Finland. The simplicity of design, also the quality of both workmanship and materials. My recommendation to purchase a Finnish prefabricated house was accepted and the order placed.

The house, which consisted of prefabricated wooden panels, assembled roof trusses, prehung doors and innumerable labeled packages, arrived here in February of this year.

The House

Our Finnish house is of simple straightforward design. It has living space dimensions of 44 ft by 26 ft, otherwise a little over 1,000 sq ft. The design calls for a large "L" shaped living/dining area, two main bedrooms and a smaller third room, a bathroom and a kitchen. Materials used throughout are wood. Wall panels are formed from an inner skin of chipboard, conventional type studding, a glass wool type insulation and an outer layer of weatherboard. After completion of the house, the outer walls are covered with wooden siding. Built-in bedroom closets, kitchen cabinets and even the kitchen sink were delivered with the house. No plumbing or electrical wiring fixtures were provided.

Of minor interest was the fact that all nails provided to assemble the house were of square cross section. A query to the manufacturers solicited the answer that such nails caused less splitting and provided better holding power.

The design of the house was such that it could be erected on a slab, over a crawl space, or with a half or full basement. We decided upon the latter alternative as we wished to provide plenty of room for our experimental systems. In this case our basement height was 13 courses of block, rather than the conventional eleven, with a large double door to bring in apparatus. This basement was of conventional American practice — 2" by 10" joists on 16" centers— with a steel beam running down the center of the house. A plywood sub-floor was installed upon which the imported house was erected.

We were very much interested in seeing how the house would go together. We employed a local contractor, providing him with a set of instructions in English and the drawings which, incidentally, were in metric dimensions. The provision of metric tapes and meter rules helped considerably. In short, the house went together with no problems. It was under roof in a matter of four days.

Flooring for the majority of the house is unique in the United States in that it is composed of thin slivers of birch set on edge, somewhat like a butcher's block, and laminated to a plywood base. Planking of this material is provided in widths of approximately 6 inches and up to 20 feet in length, and about 3/4 inch thickness. It makes extremely attractive and durable flooring.

Internal room to room partitioning is erected after the outer walls and roof have been completed. Again, this partitioning is conventional studding, clad on both sides with a very good quality chipboard, all precut to size.

Windows are delivered unglazed and are of a type common in Europe. Each window comprises two complete frames working upon a common pivot and providing double glazing which may be separated for cleaning. All windows swing inward to make this chore easier.

Systems Planning

Anyone who has witnessed the chaos upon a building site with the seemingly unorganized competition between the various trades for space and time in putting together the many mechanical facets which go into our modern homes, will have said to themselves: "There must be a better way." In our systems planning for HOMELAB, we intended to investigate one solution to this aspect. To that end, we set a basic ground rule. The house would be built, finished and decorated—in fact, ready for inhabitants—and then, at that point, the various systems would be installed, tailored to fit into the structure with the least possible disruption. In practice that meant that we could not use the inside of our completed walls to hide pipes, cables and the like. To accomplish our ends, we delegated each system to individual teams of engineers, but working in close liaison with one another. Where possible, we planned to use existing available hardware, but to adapt it where necessary to our requirements.

Electrical System

The design of the house electrical system was helped considerably by the fact that we had both a basement and an attic space under the roof. The main power distribution system took the form of the letter "H". The first stroke of the H passed along the full length of the house in the attic space, and the last vertical stroke similarly passed along the length of the basement on the side of the main supporting steel beam. The cross stroke of the H passed from attic to basement and formed the power center for the house. This main distribution system was assembled from standard industrial steel raceway sections. From this main distribution system cables are taken to lighting and power points. Although we did not attempt it in our initial installation, it is our intention to make use of this main trunk system for the application of complete harness wiring systems for the home, which could be installed in much the same way as wiring is installed in automobiles. The main trunk distribution system, together with harness wiring, will speed up on-site electrical installations by a factor of five, together with large financial savings. Furthermore, the main trunk system is flexible in giving us very little restriction for circuit additions or alterations.

All switching is low voltage. This enables us to conceal wiring to wall switches behind the trim of doorways, and to have central switching of all house lights from master control panels in the kitchen and the master bedroom. Furthermore, the low voltage system gives us a great measure of flexibility for alterations necessary to meet new experimental conditions.

The room power point problem was combined with the problem of air delivery to the rooms for heating and cooling, which is described later in the paper. Our aim was to design, construct and install for test, a baseboard system which could be applied to all the interior walls of our rooms. Not only would this baseboard system be able to conceal all power wiring, it would contain the numerous power outlets which we demand in our homes today. In addition, the design would also form the outlets and intakes of our home heating/cooling system. Of prime consideration was the provision that the baseboard should blend into the house and be aesthetically satisfactory. Several designs were made and turned into "mock-up" models for appraisal. The final approved design was for a baseboard, made of two panels, which was 8" high and protruded from the wall 2". This protrusion was greatly concealed by the sloping front of our top removable cover.

About 250 ft of the baseboard was custom made by a local sheet metal shop in 10 ft lengths. These were cut to fit the various walls inside the house. Looking to the future, this type of baseboard could be formed on-site, much in the same way as guttering is made on-site to fit the roof length.

Installation of the baseboard progressed very fast and was completed in one working day. Push-in and lock-type power sockets were used for the electrical outlets, and wiring them was both fast and easy. This type of baseboard could also include wiring for TV, phones, and intercom.

After fitting the baseboard, and just prior to its installation, slots were cut through the flooring which mated with similar slots in the base of the metal baseboard. These slots were so arranged that they passed from the below floor air distribution system into the baseboard. Concealed slotting formed in the front of the baseboard allowed air to pass to and from the rooms.

The baseboards also contain a low voltage lighting system. This is activated by a light sensitive cell so that when all main room lights are turned off at night, the baseboard lights allow one to move about the house without stumbling over furniture, etc.

Main Air Conditioning/Heating/Ventilating System

One parameter we set ourselves was to get the HVAC system out from its conventional spot in the basement. Advantages for this scheme were an increase in basement floor space, lack of noise in the living space, and elimination of danger if a gas operated system was installed. More important and with industrialized building in mind, was to design a complete modular type approach.

Our approach was to tailor the HVAC system to fit within a vertical metal frame which would include all the machinery of the system, plus such items as water heating, air cleaning and humidification — otherwise a complete package. Such a complete unit could be brought to the building site, bolted to the side of the house, air, water and power connections made. The metal frame would contain a chimney flue system, not only to discharge waste heat and odor, but which also could serve as the conventional chimney for a fireplace, if this was desired. After installation of the metal frame, the whole could be bricked over so that it resembled a conventional chimney. Thought has been given to waste heat recovery to make the system more efficient.

The winter was upon us before we could accomplish the full system described. We had to settle for an electrical heat pump system, but this was reworked to fit within our metal frame and operates totally on the outside of the house. This operates quite satisfactorily and has given us the necessary engineering know-how to modify and expand the principles in the spring of 1972, which we intend to do. Air for the complete house is delivered through the basement wall from the HVAC system outside and enters one long delivery trunk which runs down the center of the basement ceiling. Individual room delivery is made by using the space between the floor joists, which release us from the usual maze of ducting. Air return is arranged in a similar manner.

The complete system has only been running since the fall. Presently, with the aid of instrumentation, we are making an evaluation of the complete design to check efficiency and running costs. From a "human feel" point of view, we think we have an excellent system.

Water and Sewage System

Here we applied two primary considerations. First, to prevent the wastage of water. Secondly, to devise a sewage system which was independent of sewer lines, septic tanks and the like. Our attack was to consider the water/ sewage system of the house as three independent systems: drinking water (White water), washing water (Grey water) and sewage system (Black water).

Our White water, at the present time, consists of the normal city water. In the bathroom and the kitchen, special spigots have been installed to deliver this type of water.

A little over a year ago we conducted experiments to see if we were able to re-cycle all the Grey water developed from home appliances. This included water from dishwashers, clothes washers, the bath, the wash basins and showers, and the kitchen sink. Making use of flotation and the reverse osmosis principle, we were able to reuse our Grey water 15 times. Water delivered from the closed system was odor free and clear, and one did not have any hesitation in washing one's self or one's things in it. However, it could not be used for drinking or cooking, as we were not able to remove all the chemical content. We are now upgrading this system and will install it in the house in the early spring. Ultimate objective is to make this Grey water into White water and thus drinkable.

The conventional toilet is both a source of water waste and a general polluter. We have endeavored to overcome both crimes. The system developed was installed in our HOMELAB house, late in the summer. It, like the wash water system, makes use of a completely closed cycle, and was designed to contend with the needs of a family of four without any attention for a full year. The principle is fairly simple. A stainless steel tank in the basement receives the contents of the ground floor toilet after flushing. Built into the tank is an air injection system which supplies the contents with oxygen. This stimulates the bacteria into fast and vigorous action, breaking down the solids. Liquids, which accumulate in the tank, pass through large carbon filters, where small solids and the urine color is removed. After leaving these filters a small metered amount of chlorine is added and the resultant liquid passes through a pressurization pump into a holding tank. On flushing the toilet, the cistern behind it is refilled from the holding tank—thus closing the cycle. To be completely safe, we have installed a germicidal U.V. lamp in the top of the toilet cistern.

We have found that although the urine adds to the volume all the time, there is a compensation by evaporation, so that the volume of liquids within the systems remain reasonably constant. We have now operated the system for three months with success. The technicians, working on various projects within HOMELAB, have contributed at about the same rate as a normal family of four living in the house, so we have a reasonably good simulation.

At the end of the year we think we will have to remove the layer of sludge which will accumulate at the bottom of the main tank. However, we are planning to add an incinerator to the system to take care of this problem, so all that will have to be removed, perhaps monthly, will be a small amount of ash.

We have an even longer end objective. This is to combine the three systems as one, make-up water being provided by rain from the roof, so that the house will be completely independent both for water and for sewage.

There is an afterthought which should fit into the discussion of the water system. That is our electric sink in the bathroom. The challenge came from the fact that the normal bathroom makes use of mechanical means to regulate and deliver water. We felt that maybe we should give electricity a chance. We thus designed and made a bathroom sink which is operated by a series of electrical push buttons. They deliver hot, warm or cold water — either fast or slowly. They automatically open or close the drain, and one button delivers chilled water for drinking. We are not now seriously considering our sink as a product, but rather to gain people's reactions to an unusual item.

Evaluation Items

Not only is HOMELAB intended as a test setting for many different home concepts which may be developed within our own Research Laboratories but also as a place to evaluate ideas which may originate outside our company, but which may prove of interest to us.

One such item is the Barracuda plastic ceiling system developed in Sweden. This comprises a P.V.C. plastic sheet with a special edge, the whole being manufactured to dimensions 10% less than those of the room. This edge fits into and locks within a hard plastic trim strip, nailed to the top of the room walls. The plastic

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stretches giving the effect of a sheer ceiling. This ceiling is easily installed with an approximate cost of 23 cents per sq ft. If badly marked by dirt, the whole can be taken down with little trouble, washed, and then reinstalled. While our evaluation of this product is not yet complete, present indications are that such a system would have an excellent application in many of the concrete building systems now expanding in the U.S.A.

A second item is a three dimensional wall covering. This is a plastic material having a sub-miniature lens system in its surface, giving it a three dimensional appearance. Possible future application would be in the office partitioning industry, in which one of our divisions play a part. We are testing this for dimensional stability and general acceptance.

We are also interested in the use of plastics to take the place of oak on staircase treads. To that end we have developed high density polyurethane treads which can hardly be distinguished from the grained oak tread. Some of these treads have been installed on the staircase to the basement, are wearing very well indeed, and promise a reduction of cost over oak.

This trend of testing and evaluating other products intended for the home will be expanded in the coming year. One cannot expect that a householder will only buy Westinghouse products. He will, as always, have his free choice. We do feel, however, that the new and novel systems which we are developing and testing in HOMELAB should have those characteristics that make them both fit in and operate alongside many types of equipment from outside our own company, and therefore be truly flexible for many applications.

Security and Intrusion Detection

Unfortunately we live in a time when the unwelcome intruder is no longer part of a storybook, but is a fact. Our HOMELAB is an ideal site, placed among trees and isolated, for developing and testing intrusion detection systems intended for the home. Presently we have three systems developed within our Research Labs undergoing their field trials in and around HOMELAB. The direction we are taking is the design of systems which are highly reliable, relatively low in cost, and which can be installed by the homeowner himself, even if he has little mechanical or electrical capability, and require little maintenance or upkeep.

One of these systems completely surrounds the house, buried under the ground. Any person crossing this outside barrier is detected, turning on the outside floodlights and sounding an alarm. The second detection device makes use of seismic sensors, attached to the central steel beam in the basement. It can detect any person walking around in the house. The third device is a small radio transmitter which can be fitted into the jamb of either door or window. It is powered by the mechanical action of opening the door or window, sending out a radio signal to a centrally located receiver which sounds the alarm. Presently all three systems are under evaluation and will be joined by other systems in the very near future.

Conclusion

Any one of the systems described in this paper could be the basis for a complete technical paper in itself. I have tried to avoid detail, more especially the quantitative data which we have accumulated. This has not been due to secrecy on my part, but rather it would not amplify the point I wish to make.

This point is important. I feel that it will get more attention in the future. It is relatively easy from a hardware standpoint to develop both things and systems for the home. This is usually done in some form of laboratory, under ideal conditions, with a bevy of technicians always ready to adjust and modify. We seem far too ready to take gadgets and rush them into production with little thought to their end use, their relationship to other gadgets and systems, and their aesthetic relationship to the individual who will have to live with them. Numerous breakdowns and human frustrations result, and we come to think of all the mechanics of the modern home as some inhuman beast which we have to tame and subdue.

Products and systems for the home go through many stages before they reach the marketplace. There has been the tendency to get to early production stages before testing the idea before the general public or in the home. I maintain that an idea or concept should have its public trials very early in the game. This is what we are trying to do with our HOMELAB experiments.

We have had numerous visitors to our HOMELAB house. Many ask the same question: "When will it be finished?" My answer is always the same: "Never, so long as people have new ideas to be tried." This is true, for when a new and better method of doing something in the home is devised, we will rip out the old concept and try the new, otherwise we will have a museum and not an experiment.

There is a second question our visitors, hesitating perhaps, ask: "What did the house cost?" There is no secret in the answer. The complete parts for the house from Finland, including transportation, import duty, handling fees and similar minor items, cost $9,400 delivered to our site in Pittsburgh. Site preparation, including the building of the basement with sub-floor cost around $4,000. Labor cost to erect the house over the basement added a further $5,000.

One last thought. Perhaps it is early to report upon HOMELAB. I have only been able to report upon the overall project, and what we have done and are doing. Results are still coming in, but have not yet reached a point where I can present some form of conclusive evidence of results. This will come later, and perhaps I may have another opportunity of reporting to you.

25: DESIGN OF ENVIRONMENTAL CONTROLS

MULTIDIMENSIONAL SCALING FOR ARCHITECTURAL ENVIRONMENTS

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Abstract

A method of environmental evaluation is given which allows more of the subjectively relevant attributes of the environment to be analyzed in the data than is possible with traditional multidimensional scaling or normal factor analysis. The method utilizes rating scales and matches quantitative results from psychophysics, but is not limited to sensory magnitude since qualitative attributes have also been found. The method is an integrative tool for the development of environmental specification which is somewhat more efficient, relevant, and broader in scope than normal analytic approaches.

Introduction

In the evaluation of environmental quality the relevant variables cannot be specified arbitrarily; rather, it is necessary to use those attributes which are subjectively used to judge the environment if human responses are to be modeled. Once these attributes are identified, the second problem is to assess how typical environments rate with respect to the attributes, so that the physical features of the environment which influence the subjective evaluations can be quantified and utilized in partly specifying an appropriate environment.

The concept of the attribute is fundamental to this approach. An attribute is a perceived characteristic of environments, a way in which one environment is seen to differ from another. One person may call a room warm, and another term it hot, while both agree that it is warmer inside than out. Individuals may differ on their evaluations, yet still utilize the same perceptual structure. The physical features which relate uniquely to an attribute are not obvious. Temperature is related to "warmth" as a possible attribute, but is air speed? The problem of identifying attributes independent of the limitations of psychophysical methods and the verbal interface is a complex problem, and there have been several approaches.

Background

The simplest approach is to ask individuals to rate their environment on several scales, and to then compute the average for each space on each scale. There is no assurance that in such an approach the subjects are using the same interpretation of the rating scales, or that in rating only one environment they are perceiving the range of possible conditions. Words are limited. Since our environment is relatively tame, our vocabulary does not have a score of words to describe fine environmental differences, as for example, polar tribes have for snow conditions. The term glare generally means excessive light, but there are a variety of distinct perceptions or attributes inherent in the term. Thus a single rating may contain any one or a combination of several responses which should be separated in describing the environment for control through design.

Factor Analysis

Rather than dealing directly with the environmental ratings, it is possible to analyze the correlation matrix to determine if groupings of rating scales indicative of a common variable occurred. This approach has been widely used (1,2,3,4) in environmental evaluation. The environments may then be rated relative to the concepts using factor scores, but according to Osgood, Suci and Tannenbaum (5) this procedure is "conceptually clumsy and inefficient." Alternately, once identified in factor analysis, the groups of scales may be combined by some other method (6), but this approach loses the definition of each factor relative to the others which is inherent in a purely factor analytic approach.

Although the correlations between the rating scales may be the result of environmental distinctions, they can also occur because of similar phrasing of the scales or because of an inability of some individuals to distinguish more than gross differences. Another reason for high intercorrelations is that the scales used are perhaps so broad, general and marginally relevant to environments that the ratings can only be made on the most general basis. If the problem of describing environments is one of too few accurately descriptive terms relating to human responses, factor analysis may be an inappropriate tool because it tends to reduce a list of many terms to a few factors. As used, it tends to push distinguishable terms together by extracting the common variance, and entirely neglecting the unique descriptive properties of the individual rating scales.

Psychophysical and Engineering Criteria

An entirely different approach is used in experimental psychology where the environment is varied according to well described physical variables, and the human response recorded. Any controllable environmental variables can be subject to any of several variants of this research approach (7). Unfortunately, there is nothing in the approach which assesses the relevance of the variables to architectural environments. Even though repeatable responses are obtained to correspond to some physical measure, it is not assured that an attribute has been found. The response may be based on a mixture of several attributes, or a variety of physical variables may lead to the same variations in response. These too may be explored in the laboratory, but the process is a lengthy and perhaps unrewarding one.

A less innocent form of psychophysics is used in the methods of developing engineering criteria for architectural environments. Variables are explored on the basis of complaints of glare, noise, and drafts only to the extent of controlling the excesses of past technology, and rarely extending the work to avoid future problems through more understanding of human response. Under a philosophy of benign surplus, it is necessary to supply "enough" light for the most detailed task while "controlling" glare. Aside from broader environmental issues of power generation, just how much light is worth how much glare? The problem is one of tradeoffs on the perceptual level which have not been adequately explored. To answer the question the first step is to assess the perception of light quantity and the perception of glare, since without relevant attributes tradeoffs are not meaningful. Would you trade two quard for a maglevark, or are these terms possibly as irrelevant to your perceptions as illuminance and intensity?

The adequacy of engineering criteria cannot be assessed without an external criterion based entirely on human perceptions, a way of finding what are the humanly relevant attributes of the environment, and how particular environments rate relative to those attributes. Despite the previous lack of suitable assessment methods, my own observations of "well engineered" environments, and the increasing prevalence of such environments through industrialized building (8), have led to a sense of urgency in developing alternative criteria based on human responses.

Method: Multidimensional Multi-Mode Scaling

Like factor analysis the method is based on rating scales as shown in figure 1. Since the method assumes that any one scale may share meaning with the other scales, or may have several interpretations related to different attributes, the choice of terms is not critical although they do roughly delimit the scope of the study. The process involves each subject rating each environment on each scale. The data structure is shown in figure 2.

Rate: (1 2 3 4 5 6 7)
very poor — average — very good

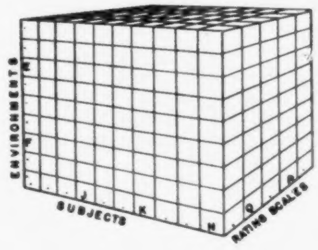
Your name ____________
Library ____________

____general impressions
____type of light fixture
____arrangement of fixtures
____color scheme
____color of light
____glare from lights
____glare from surfaces
____gross light distribution
____modeling
____quantity of light (1=too little...4=just right...7=too much)

Figure 1

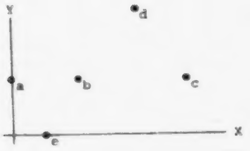
The analysis is based on the differences in each individual's ratings between different environments. On each scale, the differences in ratings between al pairs of environments (a matrix) is accumulated across individuals in a way which preserves the individually perceived attributes of the environments relative to that rating scale. The method was devised by Horan (9) and essentially makes the difference between two environments for any one scale equal to the root-mean-square of the differences in ratings by each individual.

A possible matrix is shown in figure 3 with a configuration of points which represents the environmental differences as distances. As shown in figure 3, these distances may be adequately modeled by the use of two dimensions although five environments could require as many as four dimensions. The term 'dimensions' is



$$D^{P}_{EF} = \sqrt{\sum_{J=1}^{J=N} (X_{EJP} - X_{FJP})^{2}}$$

Figure 2



	a	b	c	d	e
a	0	2.0	5.0	4.4	2.0
b	2.0	0	3.0	3.0	2.0
c	5.0	3.0	0	3.0	4.4
d	4.4	3.0	3.0	0	5.0
e	2.0	2.0	4.4	5.0	0

Difference Matrix

X	0.0	2.0	5.0	3.5	1.0
Y	1.7	1.7	1.7	4.3	0.0

Dimensions Matrix

Figure 3

used rather than 'attributes' because the locations of the axes representing the dimension is arbitrary which is not appropriate to specification of an attribute.

Interrelation of Dimensions

Given two such matrices, the dimensions may overlap allowing both matrices to be reproduced using the same axes, or it is possible that no overlap would occur. Carroll and Chang (10) have developed a program for analyzing sets of matrices into a single matrix of common dimensions and a set of weights which indicate the relevance of each of the dimensions in reproducing the differences in each of the original matrices. One matrix representing the differences from one question may relate to only one or several of the dimensions and this would be shown by the weights. Typical results from the analysis are shown in figure 4. The properties of the solutions have been explored (10) and to date the axes specified as a result of the analyses have been unique and psychologically meaningful. Only one set of axes can result because of the requirement that multiple matrices be reproduced by the results. If the data for this analysis is a matrix from each rating scale for the differences between environments, then the result is a unique set of axes in which any one axis may be related to several rating scales, or any one rating scale lead to several different axes which may or may not be related in turn to other rating scales.

RATING SCALES	ATTRIBUTES I	II	III	Corr
General Impressions	.68	.40	.25	0.85
Color of Surfaces	.24	.61	.45	0.83
Color of Lights	.84	.16	.15	0.88

RATINGS	SS	LD	RR	MT	C	H	M	K	B	W
I.	.30	-.37	.09	.38	-.11	-.63	-.22	.06	.38	.12
II.	-.35	.35	.11	.38	-.63	.32	.00	.20	.21	.12
III.	-.33	-.15	.52	-.58	-.25	.07	.16	.30	.00	.27

Figure 4

Such axes satisfy the requirement to be termed attributes since they are unique and entirely based on subjective responses and are somewhat independent of the limitations of the language in conveying the responses through words. In effect, the words used in the rating scales serve only in a relative sense and drop out in the analysis, just as any length can serve as a yardstick in assessing differences in distance. The attributes indicate differences between environments on a scale which may then be used to compare the attributes to possible physical measures of the environment. Perhaps more significantly, the attribures are based on the more perceptable environmental differences which in turn is an indication of relative importance, thus allowing the more important variables to be considered first in research. Once these variables can be specified, laboratory research can further clarify detailed relationships. It is, of course, necessary to assure that laboratory responses to model environments do follow responses in the field if the research is to be translated back into relevant criteria, a problem too often unassessed perhaps due to a lack of appropriate methodology. The validity of various kinds of modeling can be accurately tested through multidimensional multi-mode scaling, using **the** hypothesis of parallel attribute ratings.

It should be mentioned that Wish (11) first applied this form of multidimensional scaling to rating scales, but in following more closely the work of Carroll and Chang, he computed the matrix of inter-environment differences across all of the rating scales, thus finding the relevance of each attribute to each individual rather than to each rating scale. This approach was less successful with environmental data than the one described earlier except where a single rating scale with relatively low random components was analyzed to produce two correlated attributes. In any of these analyses the axes are not constrained to be orthogonal, but it is difficult to ascribe any correlations to the nature of the attributes because of the possibility of chance relations in any small set of environments chosen.

Application: Scaling Ten Visual Environments

Using the scales in figure 1, ten library reading rooms were evaluated by 110 students in architecture. The students visited the chosen environments at night in small groups. Each group went through the rooms in a different order, spending about twenty minutes in each room. While the absence of daylight certainly had an effect on the data, there were no particular attributes which could be considered unique to students or to libraries, thus suggesting that the results could be applicable elsewhere.

Factor analysis of the data showed a pair of dimensions, one relating to overall quality, and the other relating to the two glare scales which indicated that the otherwise better environment had a greater glare problem. A more realistic multidimensional analysis of the inter-environment differences for each rating scale showed six dimensions, one mixing color and quantity of light with overall evaluation, and the others relating to distribution of light, the color schemes, the fixture type and arrangement, the glare from the lights, and the glare from surfaces. Since six dimensions resulted in multidimensional space capable of holding only nine, there was a serious possibility of overlap artificially reducing the number of dimensions. To prevent this reduction, the analysis was repeated for subsets of the rating scales and resulted in more attributes. For example, the one dimension relating to both fixture type and arrangement split into one attribute which was an assessment of the "gestalt" of the fixture pattern, and another attribute which related to fixture shape and individual appearance. The analysis of the quantity of light question was conducted using Wish's procedure for only one question, resulting in two attributes which were highly correlated but distinguishable.

Results of Analysis

There is too much in the way of results to be adequately discussed here with fourteen dimensions each with a previous research literature and separate conclusions, so a few illustrative attributes will be discussed in detail and the remainder summarized. One attribute related to quantity of light related directly to the footcandle level as measured by the IES averaging method (12). As can be seen in figure 5, where the attribute ratings are graphed relative to both the mean ratings and the footcandle levels, the preferred level was 40fc. While this agrees with IES recommendations of 30-70 fc for libraries (12), it is far less than typical installed levels. More than this level was seen as too much light, less as too little, although not at a very great rate, since a change of 50% in illumination moved the rating by only 0.7 on a 7 point rating scale. It is interesting to use the mean ratings relative to the footcandles to compute the exponent in Stevens' formula which suggests that response magnitude is proportional to the stimulus magnitude taken to a power, $\psi = k\phi^n$ (13). For the brightness of a 5 degree spot Stevens found an exponent characteristic of the visual process of 0.33. The exponent for this data relating the mean ratings to the footcandle level is 0.35. This suggests that the ratings and this kind of differential analysis can approach a ratio scale. It should be noted that the scaling automatically produces subjectively relevant intervals. Thus, equal percentage changes in illumination are seen as equal and the difference between 10 and 20 fc is not the same, perceptually, as the difference between 100 and 110 fc.

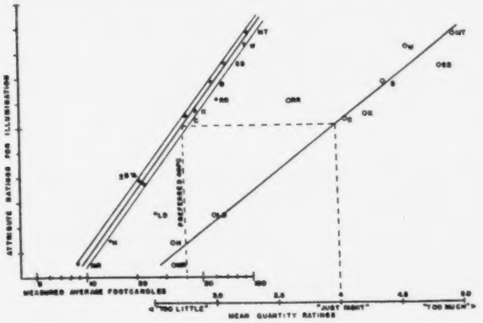
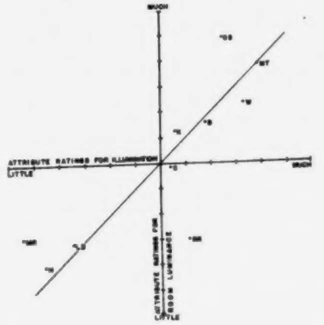


Figure 5

The other attribute relating to quantity gives weight to the luminance of the walls and may be called the room luminance. In most cases it is directly related to footcandles, but an environment with highly reflective walls, or a very dim room illumination relative to local lighting levels, rate quite differently from the norms (RR,SS) as shown in figure 6. Architects have long suspected that footcandles are not a complete measure, and this pair of attributes indicate that two measures are needed to describe the quantity of light perceived. Those designers who would question the relevance of footcandles altogether were proven wrong by the first attribute.

There is still some question why 40 fc was the preferred level. Several minutes was allowed before entering the rooms and more time in the room before answering the question, so there is no adaptation effect (12). Glare is a possibility, as shown in figure 7, but there is one environment with little glare and too much light (B) and another with too little light and glare (H) so the connection is not complete. Too much light is simply too much light, a re-

Figure 6



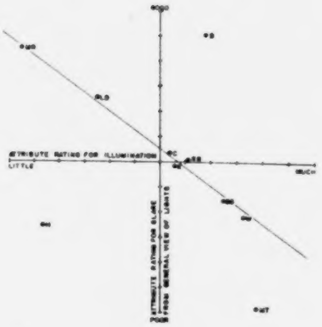


Figure 7

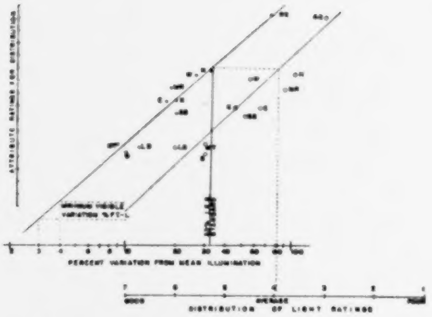


Figure 9

sult not anticipated by current engineering practice and research.

A high luminous ceiling reduces glare below the norm (B) but a low luminous ceiling does not (LD). Small intense spotlights (H) or a rectangular grid of fixtures producing an op-art effect despite moderate luminances (MT) can produce more glare than the norm. A second glare attribute relative to the first is shown in figure 8. Here three environments are relatively poor, two (H,MR) have small fixtures, while the third (K) is almost identical to a higher rated environment (C) except that the fixture edges are much less distinct. The second attribute is related to the direct view of the fixtures, while the first relates to glare perceived while observing the room as a whole. Glare criteria (13) provide for only one attribute and do not adequately model the human response. It may be noted here that the evaluations of glare represent an integration of the variety of fields of view not just the one view point used in engineering evaluations. With this kind of result, the architect would be advised to either have a high luminous ceiling, or keep the fixtures large and distinct, without op-art patterns. The main cure for glare, however, is a reasonable illumination level.

Another attribute was related to the distribution of light. Figure 9 shows a graph connecting these attribute ratings to both the percent variation in illumination on the working surfaces and to the mean ratings on the scale. A 33% variation is the IES standard (12) which subjectively corresponds to "average" although all but one environment exceeded this criterion. There is always some question about the meaningfulness of the ratings especially at the extremes. If, for example, the rating of "7" corresponds to the best that can be seen, then it should relate to the minimum variation in luminance that the eye can see. This minimum modulation rate has been measured (14) at 3 or 4% which does correspond well to a rating of "7". Just how meaningful all the scales are remains subject to further work, but where specific stimulus levels could have some subjective meaning, there have also been indications of specific mean ratings.

The quantitative results are matched by qualitative ones; the scaling methods make no distinction between aesthetics and psychophysics. The color scheme was evaluated by two attributes, one relating to the presence of bright colors favorably, and the other relating more to rich but muted natural wood colors. The first attribute may be interpreted as "colorful/colorless" and the second "organic/plastic". The term "plastic" applies to the presence of artificial bright colors. Thus, an environment rated highly as "colorful" may be

Figure 8

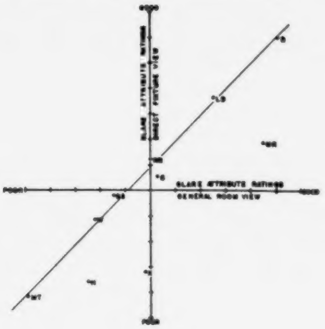
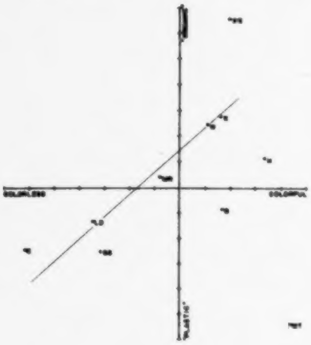


Figure 10



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downgraded as "plastic" (MT). The two attributes are graphed relative to each other in figure 10. The best overall environments (W,K,H,RR) had much natural wood. Just to illustrate how far astray laboratory research can lead, a massive program of rating colors was recently undertaken (150,000 ratings) but no wood samples were included (15). The attributes are not unexpected, although a stronger emphasis on organic colors might be found in students than in the population as a whole. Attributes which have not been previously mentioned are summarized in the following: Glare from surfaces: two attributes relate to reflections from desk tops due to concentrated light sources and specularly reflective surfaces, and to reflections from windows at night which were not covered by curtains or other coverings. In that such objectionable features were avoided in some designs, they can be eliminated as problems in the visual environment. Color of light: Warm white fluorescent was seen as better than mixed warm and cool and better than cool white. Low level incandescent was rated poorly perhaps due to yellowed diffusers. Mercury vapor rated very low even though "color corrected." Modeling: spot down lights were too harsh, and luminous ceilings while not as poorly rated did poorer than standard rectangular fixtures. Both extremes could be avoided.

Architectural Implications

The attributes, once understood, are relatively easy to consider in design. Perhaps the best way to grasp them is to visit the spaces with a score card, or to view the spaces through slides, but many aspects are not as easily seen through the distortions of photography. Since many of the environments had serious faults, these form the basis for a large number of the attributes and the faults may in turn be identified and avoided in design. It is important that examples exist which illustrate the faults and that they have occurred in modern architectural designs. Such problems do not just happen to other architects, but are likely to occur in anyone's practice. Some of the faults are due to misapplication of new technology, such as mercury vapor lights, and excessive illumination levels, which could be eliminated given sufficient experience. Technology is changing quickly so that the slow process of gaining such experience means that many poor environments will be produced before the problem becomes common knowledge. A professionally oriented evaluation system could avoid these problems through adequate assessment before installation, or at least in coordination with the initial use of new technology. Properly armed, the profession need only make the same mistake once.

The more positive benefits of providing good illumination without glare (B), a color scheme acceptable to both kinds of perceptions (H), good fixture arrangements (LD,B,RR,MT), and other highly acceptable features can serve as models to be bettered in future designs. Too often designs are done "new" without identifying the best of what has been done and trying to improve upon it in definable ways. There is little continuity to the profession, perhaps due to a lack of methods for evaluating the success or failure within a coherent and communicable research structure.

It is regretable that better examples of the achievements of the profession could not have been used in this research. Had they been used, it might have been possible to begin to point out how really good architecture is related to the everyday variety by connecting both types to the same attribute structure. Technical adequacy does not assure great architecture, but it would be a perverse definition of greatness which did not include making an environment acceptable to the occupants.

Research Implications

It is now possible to do research on the quality of the sensory environment in architecture using the built environment as a laboratory and to obtain results comparable to psychophysics while still including qualitative assessments. Although the technique uses rating scales, thus minimizing the subjects' effort and research time, it does not depend on the assumptions of common interpretation of the rating scales but assumes multiple and interrelated meanings among the scales.

It does, however, relate the attributes to particular scales and provides a weighting of each scale on each attribute, thereby resembling factor analysis, but far exceeding the ability of factor analysis in identifying separable attributes used to perceive environments. No secondary step is necessary to scale each environment on each attribute, since this occurs as a natural part of finding attributes which discriminate between environments. The attributes are selected on their value in reproducing discriminations of human observers. The technique can replace factor analysis wherever the same observers have rated several environments. While the technique is a variant of multi-dimensional scaling, it does not require the tedious paired comparisons normally used and can achieve results which match those of sophisticated non-metric scaling procedures (10,11,16) without requiring large amounts of computer time for additional iterations. Traditional multidimensional techniques do not locate the axes uniquely, while the requirement of matching several matrices with a single matrix allows this matching to occur with the new technique. Although not discussed here, the technique was originally developed for analysis of single criterion (similarity) judgments of pairs where each person's data provided a single matrix and should prove useful in the analysis of environmental data collected on this basis, especially in locating unique axes.

The technique is general, in that any rating data may be analyzed. Hopefully nothing in this paper has suggested that the approach be limited to sensory environment. Wherever it is presumed that coherent discriminations occur between environments, these presumptions may be checked and made a matter of research record using this method of scaling. The application ranges from the friendliness of environments, to the aesthetics of color and form.

In the particular area of research discussed in detail here, it is apparent that engineering criteria for sensory environment only begin to model human perceptions and that there is now an approach which can define the nature of the criteria which are needed. Given more definitive research involving larger samples of environments of differing purposes, it will be possible to rewrite the criteria on the basis of the relevant subjective responses.

Perhaps the major implication for research and the profession is that there exists a way of saying, "This environment is better than that because a large number of observers see a quality difference relative to some attribute." Given the ability to make such statements on the basis of occupant judgments, it is now possible to learn what architecture is in the senses of the occupant. Then it is possible to begin to develop criteria making architecture what it should be relative to those perceptions.

Acknowledgments

Peter Kimmel and Steve Suzuki participated in the design and conduct of the survey and in the initial analysis. Gail Wong provided the sketches and din Vu did the floor plans. The larger debt is to the students of Architecture 110, Fall, 1970, who participated in the exercise.

Footnotes

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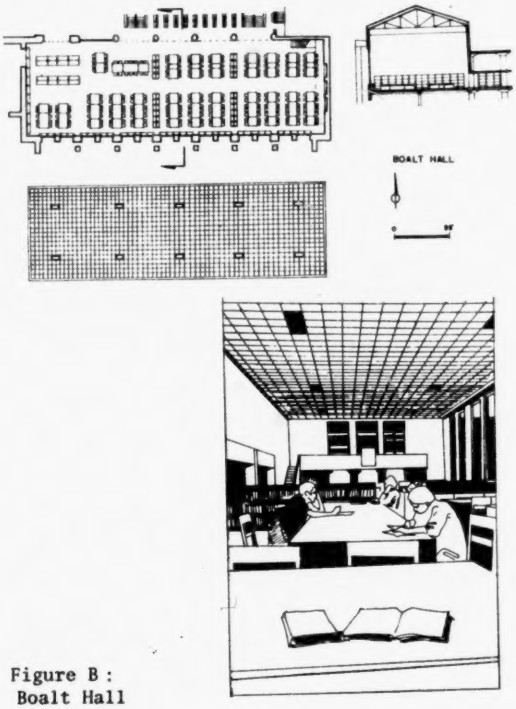
BOALT HALL
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25'

Figure B :
Boalt Hall

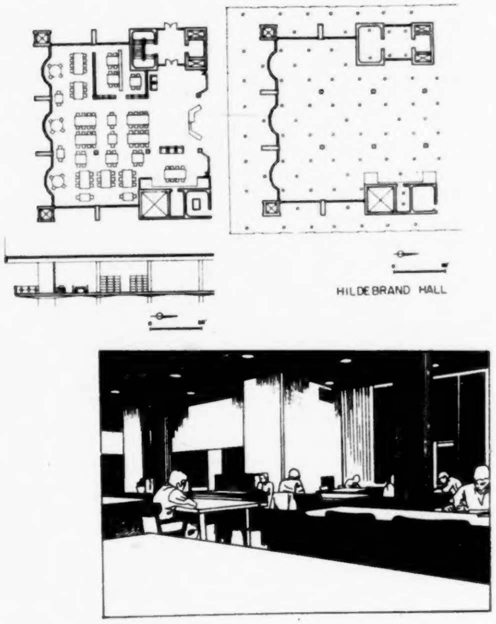

HILDEBRAND HALL

Figure H: Hildebrand Hall

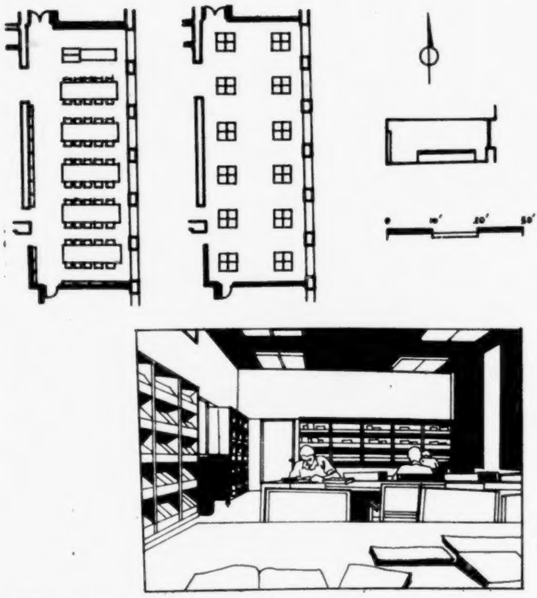
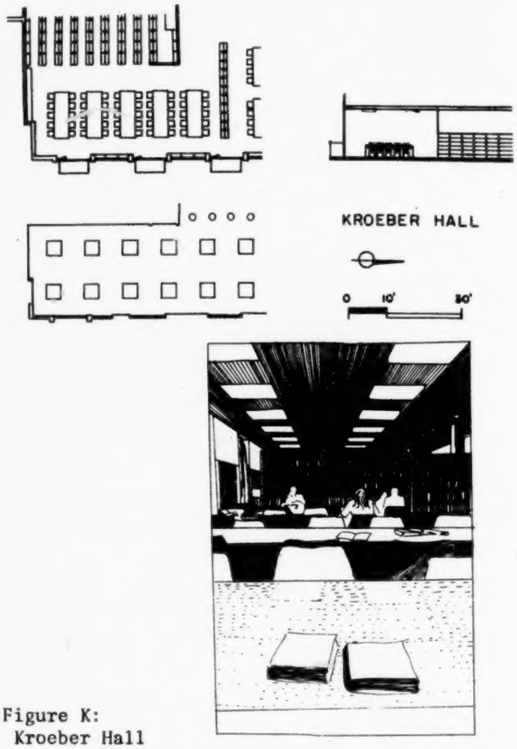


Figure C : Campbell Hall


KROEBER HALL
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10'
30'

Figure K:
Kroeber Hall

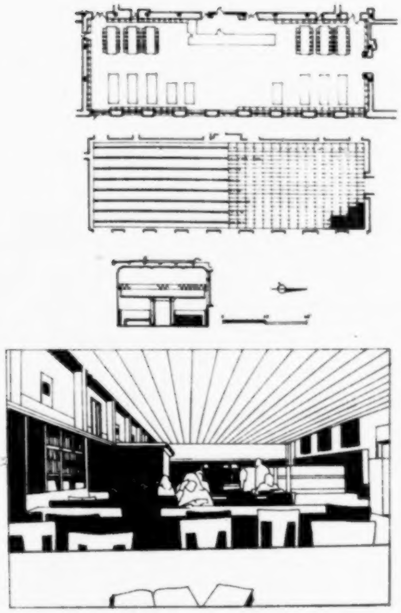


Figure LD: Loan Desk

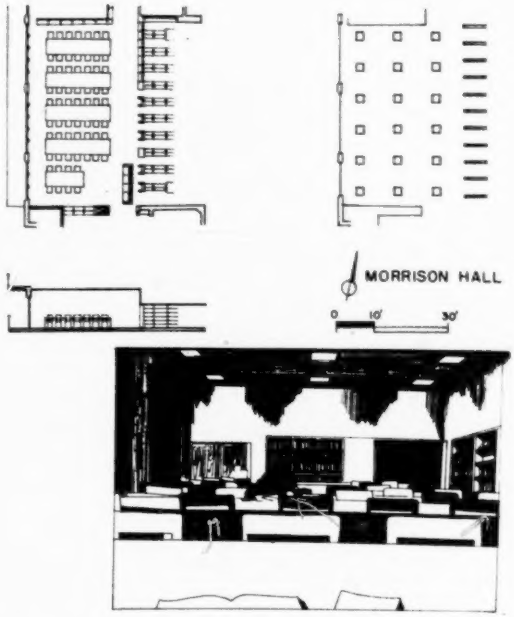

MORRISON HALL
0
10'
30'

Figure MR: Morrison Hall

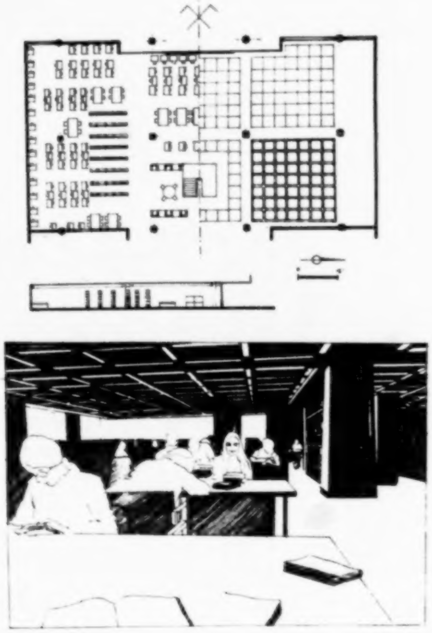


Figure MT : Moffitt

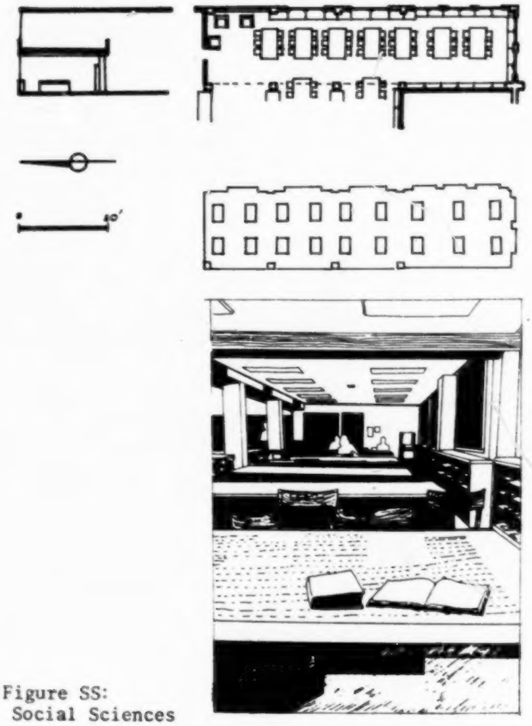


Figure SS:
Social Sciences

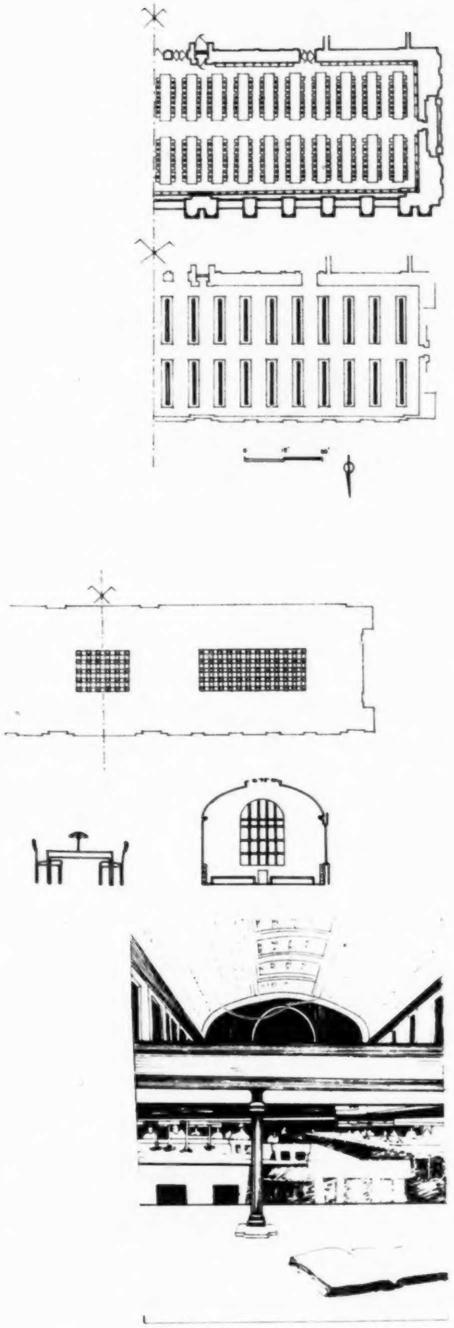
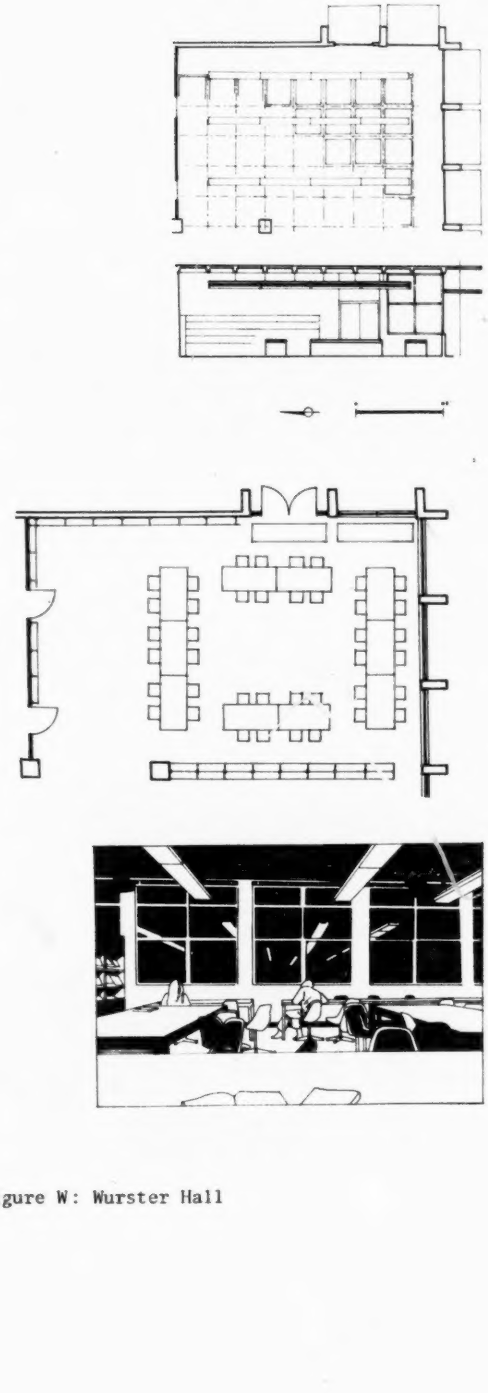


Figure W: Wurster Hall

Figure RR: Reference Room



INTEGRATED ENVIRONMENTAL DESIGN OF BUILDINGS

Professor P E. O'Sullivan

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Introduction

Historically, the concept of buildings as a means of protection against the more inimical natural elements, predators and the like has gradually given way, with social and cultural development, to increasingly sophisticated control and modification of the natural climate in the interests of more efficient and comfortable participation in more and more complex human activities. At any given time the degree of success has been related to the state of scientific and technological development. The former has made possible increasingly accurate specification of psychophysical conditions for optimum efficiency and comfort, the latter the means of achieving them with greater certainty. Though relationships between cause and effect are far from simple, theoretical knowledge has usually been in advance of applicable techniques, and fragmentation in the interests of deeper specialised knowledge (as in the medical sciences, for example) has tended to produce isolated techniques for the better achievement of specifications - whether visual (eg the glare indexes of the IES Code) [1] thermal (eg Webb's work on effective temperature) [2] or aural (eg the Dutch work on the sound insulating properties of glass) [3] - to accord with the individual criteria emerging from specialist studies in depth of each aspect. It is only recently that efforts have been made to bring together a number of environmental and building design factors. It is the intention of this paper to trace the brief but important history of these efforts in Great Britain and the effects they have had on building design.

Integrated Design

The concept of integrated design adopted in this paper recognises that the building itself, its fabric, shape and relation to local climatic conditions, its effect on those conditions and its internal organisation of space, are no less important than installed services in effecting a close relationship between internal environment and known physical optima for human comfort and convenience, with economy and efficiency of means; in short, in designing an effective filter between man and his natural environment. On occasions, environmental effects resulting from decisions about the building itself through the subsequent installation of services. Such a concept demands a new rationale of collaboration in the design process. The participants, building owner or client, the design and building teams all contribute toward a common and comprehensive view of long and short term aims. All share the decision at the inception of a project to integrate design factors for which they are normally individually responsible. Furthermore, decision making thereafter becomes a concurrent process in all the disciplines involved in and not sequential (and, therefore, logically isolated) as in the normal case of building design.

The Environmental 'Era'

It is important to note, yet not generally recognised, how new the current approach to environmental design is, for it can well be argued that the environmental era began 'officially' in November 1967, when the Institution of Mechanical Engineers held their Conference on 'Heating and Ventilating for a Human Environment'. For this reason the results, although fully documented are worth summarising here.

Billington [4] and Crenko [5] in the separate ways, reviewed the work on discomfort. They indicated that under 'stress' conditions, increasing the air temperature, varying the humidity and rate of air airflow, and increasing the Effective Temperature, could and indeed had been correlated with a fall off in productivity and Health, and an increase in industrial accidents. However, when 'stress' conditions did not apply, for example, in air temperatures of 20°C or less, comfort conditions were assumed to occur. In this 'region' no optimum standards had been determined, nor indeed what tolerances existed. What was true in the Thermal Environment appeared also to be true in the Acoustic Environment [6].

The state of the Art of Heating and Ventilating [7,8] was widely discussed, mainly in terms of 'hardware'. The control of the thermal environment, however, appeared to be easily 'dismissed' with such statements as .... if 'normal' heating and ventilating is unable to cope with the internal conditions, and in some cases this happens, then Air Conditioning can and must be provided ..... either by traditional or by packaged units [9]. The implication being that Heating and Ventilating plant sometimes in the form of air conditioning, can and will solve the environmental problems created by the building, albeit at a cost. Further, that the key to this problem solution was through Controls and Control Theory. New and better controls, with increased rates of response, for example, would make up for the deficiencies of plant and buildings.

The cost of building services, both as a total and as a percentage was increasing rapidly. The suggestion was that this cost could be offset to some extent by 'standardisation' always allowing that 'flexibility' was maintained.

So the 'traditional' service arguments were restated as they had been done so clearly for many years. The picture which emerged was that of a technology, highly developed but with no theoretical base to relate it to 'buildings'.

However, at this same Conference where the traditional view was so powerfully put, the beginnings of a new Concept emerged.

The Concept of Climatic Modification [10] in which the building is considered as a filter between man and his environment, a filter between the meteorological climate on the one hand and the required private climate on the other 'appeared'. This filter was considered to have three sections. Namely:

a. The conversion of the meteorological climate of the region, to the correct microclimate around the building.

b. The modification of this microclimate by the properties of the Building Envelope itself, ie, by the properties of the materials in construction.

Further, that it was these first two stages combined, which should act as the course control on the environment to produce the (basically) correct internal climate. That mistakes made in (a) and (b) could not be rectified in stage (c) which consisted of the 'fine tuning' of the environment so produced, by the thermal plant, the lighting etc.

Inherent, in this concept was a numerate based probabilistic view of design, which can be summarised as .... 'you can never be absolutely right, so how wrong do you want to be?'

Stage (a) above was further set on a firm 'climatic' basis by Lamb [11] in his discussion on Heat Islands.

Force was added to the argument in Stage (c) by Eccleston [12] who showed how the performance of thermal plant was dependent on the building envelope. Finally, Scott [13] demonstrated that these new ideas, required a new role, that he and other people were already beginning to define.

Window Function

This concept of Climatic Modification, with the emphasis on the building as the prime control, was seen by some Architects and indeed some Heating and Ventilating Engineers, as a means of establishing a new route through the problem of environmentally uncontrollable buildings and the attendant blame that attached to them. An analysis of this problem was, attempted under the heading of 'window function' [14].

Window function may be regarded as three fold: to provide planar illumination (the specified level determines the area of glass required); to provide a directional component in the lighting (which varies with shape and position of windows); and to provide a view out (which may determine the number, the size, and to some extent the position of windows). A basic environmental design decision is how to allocate priorities to these three functions, and how to combine them in such a way as to achieve a specified integrated environment. The relationships of window function to the principal aspects of the physical environment are dealt with separately and collectively below.

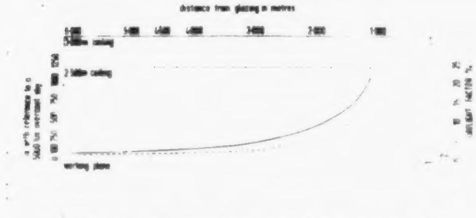
The Visual Environment

A fixed quantitative standard for natural lighting has three 'effects' on building design:

a. For a given floor to ceiling height it limits room depth (Fig 1) or restricts the buildings to a single storey, unless clerestory windows or roof lights are used to augment the unidirectional lighting.

b. It produces designs with a high ratio of external wall area to internal volume.

c. It produces designs with a high proportion of glazed to unglazed external wall.



distribution of daylight on the horizontal working plane within a room 3·000m wide and 6·000m deep with 2·500m and 3·000m ceiling heights, the glazing is from cill to ceiling and wall to wall with an unobstructed sky

—— 3·00m ceiling - - - - 2·500m ceiling

DIAGRAM ILLUSTRATING HOW DAYLIGHTING REQUIREMENTS CAN LIMIT ROOM DEPTH

For example, a 2% Daylight Factor (DF)[15] related to the standard overcast CIE sky of 5000 lux produces minimum internal illumination of 100 lux, but of course sky brightness varies. In the United Kingdom this variation is such that, during an average year, 100 lux is achieved or exceeded for 84% of the periods during which offices are occupied (0900-1730) [16].

Recommended levels of planar illumination have risen progressively with rising standards of living. The IES standards [17] reflect this. Clearly, if these recommendations are met for only about 50% of normal working hours, the point has been reached at which it is impossible to meet them in rooms of economic ceiling height merely by increasing the area of window. (Many offices built to the 2% DF already have cill to ceiling and wall to wall glazing, and any increase in window area would necessitate an increase in ceiling height). Furthermore, large areas of glazing produce 'sky glare' discomfort under certain conditions of sky luminance, irrespective of orientation 17. High brightness sky may be the area of greatest luminance visible from inside the room, causing serious visual distraction and a serious reduction in visual acuity. If, in addition, the windows admit direct sunlight, excessive luminous contrasts can result, reducing visual acuity still further, and possibly producing reflected glare from specular surfaces, and so still greater visual discomfort.

The distribution of daylight within a sidelit room (Fig 1) is such that the illumination levels close to the windows are very high compared with the levels at the back of the room, particularly, if it is more than 4·8m deep. For example, in an office with no rooflights and designed to give a minimum of 2% DF at points most distant from the window, there could well be a 20% DF near the window wall. Though the quantity of daylight reaching the rear of the room is 'adequate' in terms of the recommendations, it appears gloomy by comparison, and artificial light is used for subjective, as apposed to funcational, reasons. It can be seen, therefore, that in buildings with windows designed for planar illumination, artificial lighting is often used and/or blinds may be drawn [18] to reduce visually uncomfortable luminous contrasts between the sky and room interior or within the room between the working areas near to and distant from the window, to prevent excessive brightness contrasts due to direct sunlight, or simply to augment 'inadequate' illumination levels. Blinds reduce sky and sun glare. Artificial lighting improves the luminance distribution over the room area and increases planar illumination when necessary. Both are needed where windows are designed in terms of planar illumination only. They do, however, provide also a directional component, necessary for clear visual resolution of solid or modelled objects [19] and for the psychological desirable outward view. It would seem, therefore, that since planar illumination can be artificially augmented, it should no longer be paramount, and that the latter functions should be given greater priority in window design.

Thermal Environment

The application of 'climatic modification' to the thermal environment, resulted in the emergence of the idea of a 'Balance Point' [20] which may be described as follows.

It is possible to plot on a graph of axes external air temperature v heat input, both the heat losses from a building which increase approximately linearly with decrease in external temperature, and the heat gains to a building which increase with increase in air temperature, but not linearly. An example is given in Fig 2.

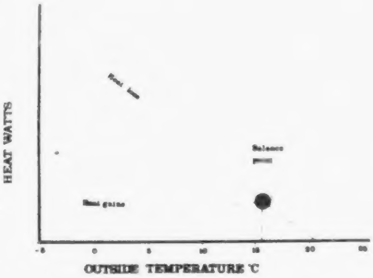


Figure 2

The point where the two curves cross is known as the 'balance point'. At all external air temperatures above the 'balance point' the building is self-sufficient in heat, albeit in some conditions uncontrollably as the upward swinging heat gains curve shows. The balance point shown is that for a 15m wide, 2% DF building with 70% of the external wall glazed and balances at 16°C. It, therefore, requires heating whenever the external air temperature falls below this value and conversely it may require cooling and that of a large order when the external air temperature rises.

The effects of the various design steps that might be taken to improve this thermal 'state' of affairs are shown in Fig 3. For example, the effect of reducing the U-value of the opaque parts of the wall from 0·7 to 0·57 W/m^2 deg C is quite small: the heat loss curve moves from 1 to 2. Reducing the area of glass from 70% to 20% reduces the heat loss from 1 to 3 and increases the heat gains from B to A. In other words, it is possible to draw a diagram of the effects on the thermal properties of the building, and therefore, on its thermal performance, of design decisions concerning, windows, materials and so on.

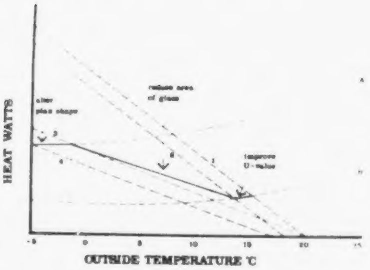
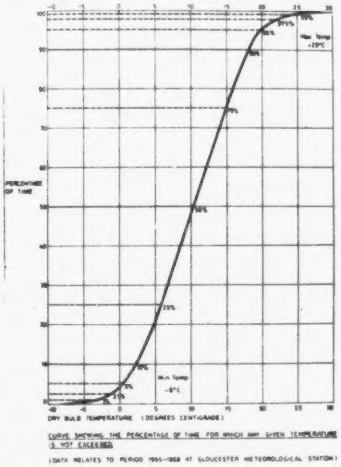


Figure 3

The idea of 'controllable' building, ie, one which acts not only as a control on the external climate but also as a control on both the total heating/cooling requirement and the time for which that applies had emerged, and what is more, emerged as design based.

During the same period further work on the external climate, [21,22] defined more clearly the existence and potential of heat islands, that is, the increased air temperatures found in cities, which can be correlated with urban density. This work when linked to the new 'probabilistic' view mentioned earlier, produce, and is still producing from the results of a computer analysis of all the British Meteorological Data of Dry Bulb Air Temperatures, temperature curves such as Fig 4 [23] which give the probability of any external air temperature occurring at any time. It is this work which enabled the theoretical concept of a Balance Point to be put onto a predictive design basis.



CURVE SHOWING THE PERCENTAGE OF TIME FOR WHICH ANY GIVEN TEMPERATURE IS NOT EXCEEDED

(DATA RELATES TO PERIOD 1965–1969 AT GLOUCESTER METEOROLOGICAL STATION)

Figure 4

The concept of climatic modification and the attendant balance point theory have centred a great deal of research interest on the building envelope in the last five years (eg 24,25,26,27). From this work it can be concluded that the better the climatic modification characteristics, the lower the heat losses and hence the easier and 'cheaper' it is to control the internal thermal environment. Taking window function again in this context, the larger the 'proportion' of glass in external walls the greater will be the effects of solar overheating and radiation and/or convective cooling, producing greater heat losses through the fabric by conduction and radiation, greater heat gains due to radiation, larger building air temperature swings, greater difficulties in thermal control, and more complaints of unsatisfactory thermal environment. These problems, directly related to glass area cannot be overcome merely by air conditioning[28,29,30] or my manipulating the thermal properties of the opaque parts of the building enclosure.

The case, therefore, for reducing areas of glass was made and resulted in conclusions such as those shown in Table 1[27].

Table 1: Limits of glass areas as a percentage of total area of southfacing facade (no external screening)

	Thermal environment is uncontrollable even with current standards of air conditioning	Thermal environment is controllable with current standards of air conditioning	Thermal environment may be controllable with mechanical ventilation only
lightweight single glazing	greater than 60 per cent	60 per cent or less	20 per cent or less
construction double glazing	greater than 50 per cent	50 per cent or less	20 per cent or less
heavyweight single glazing	greater than 75 per cent	75 per cent or less	20 per cent or less
construction double glazing	geater than 65 per cent	65 per cent or less	40 per cent or less

The Acoustic Environment

The continual increase in external noise levels (eg, urban traffic noise) had made urgent the problem of preventing penetration of noise into buildings. Recent fieldwork on the sound insulation characteristics of windows demonstrates that, of the external noise penetrating a window wall, approximately, 90% comes through the windows, and more than half of this through cracks around the edges of the windows - ie, it is not a simple area effect as in the case of solar overheating[23]. Unless windows are sealed (with all this implies in terms of artificial ventilation) and made more acoustically efficient, there is, once again, the conclusion that window size should be reduced.

The Total Environment

In 1968 these 'sets' of results began to come together. As a result of 'climatic modification', buildings which were both thermally efficient and comfortable were wanted, and for perhaps the first time designers clearly understood how to produce them. There was also a desire to design and produce thermal plant, matched to these buildings, which would be economic and efficient.

As it is not possible (except for very specialised purposes) to design a building in the United Kingdom that will require heating all the time, the decision was taken to produce buildings that required no heating overall, ie, were self-sufficient in heat. However, a building balancing at, for example, 0°C poses several problems in practice. For self-sufficiency in heat overall does not necessarily mean the right amount of heat at the right time in the right areas, since some areas tend to produce too much heat some too little. Traditionally the excess heat would be thrown away and new heat generated for the heat starved areas. Could not the excess heat produced (which had already been paid for) be collected and transferred to parts of the building that need it? The answer was 'yes' as a result of a new idea in air conditioning, namely, 'heat recovery'.[33]

The idea is as follows. The heat producing areas (people and light in offices; people, light and machinery in production spaces) have their excess heat removed by a cooling air load. This load is designed to be as stable as possible as a result of the thermal properties of the building enclosure. The heat now in the air is then recovered by a heat recovery coil instead of being thrown away and redistributed to other parts of the building. Finally, any excess heat is thrown away.

In fact, if the buildings were thermally efficient and the heat loss was low, a large proportion of the heat would be continually thrown away during working hours, so that a further development to enable that heat recovered to be stored during the day and then used to preheat the building next morning, could occur.

Consequently, the following decisions were made: for lighting purposes, windows would be designed to produce a directional component of light and view out only; planar illumination would be provided by electric lighting; window area would be reduced to approximately 20% of the external facade, and the general thermal and acoustic properties of the fabric would be designed to give the best possible combined performance in terms of heat loss, heat gain, temperature swing, and human 'comfort'.

These decisions have now been applied to a number of building types [34] of which the most significant are, the Wallsend Building [35,36] the Eastergate School [37], the Liverpool Daily Post and Echo Building, [38] the Simon Building, Stockport [39], and the Bentalls Store, Bracknell [40].

It is important to remember that these buildings, perhaps, more properly described as 'controlled experiments', built through the process of Integrated Design, have only recently come into use. So that although these buildings were instrumented in order to record the energy balance and the resulting physical environment, results have to date been scarce and are only now available for analysis. Similarly, the way people use these buildings, the 'human end' evaluation, and to ensure that, for example, the visual environment has not deteriorated as a result of improving thermal and acoustic performance has just begun. Hence, conclusions drawn from them can only be tentative. However, the indications are:

(i) The ability of these buildings to produce and control the desired internal thermal environment is established.

(ii) User reaction to the Environments so produced appears to be favourable (see 'filmed' evidence).

(iii) Predicted economics of capital and running costs have been realised.

(iv) The balance point concept, although necessary to the design of a 'controllable' building, and to explain to the design team how the thermal parameters interact, where the economic break points are, and therefore, what heating and/or cooling system should be used is unfortunately of no great help in designing the actual system itself.

(v) Furthermore, the balance point tends to lead to over optimistic assumptions of how much heat can be recovered, is worth recovering, and what can be done with it. For example, it can lead one into designing complex controls to operate basically simple plant, in order to recover that extra 2% of heat.

(vi) Integrated Design can lead to the establishment of a method which can be described as the 'mesh'. This occurs when a set of building performance parameters are first established and 'meshed' against a set of 'human' parameters to produce the required internal environment, and appears to suffer from two disadvantages. Firstly, because of the very way that thermal plant operates, it tends to produce regular environmental conditions, and secondly, because the human parameters have been based on 'comfort' conditions (established by 'lack of complaint' and personal opinion), the results are not as universally satisfactory as was originally hoped.

Further as the building parameters were the only ones that were based on actual evidence, the evidence, two parallel research programmes must also be considered:

(a) As 'comfort' conditions were not defined and appeared to span a wide range of which no one knew what the tolerances were, the idea of a 'swing' of internal building temperatures emerged as a means of reducing plant costs and size, [41] and attempts to define acceptable swings began. The author's own current research work leads him to believe there is in fact no such thing as 'comfort', but that there are three zones, namely, discomfort; lack of discomfort; and pleasure. Current knowledge enables one to design in the 'lack of discomfort' zone, but there is no information, but plenty of opinion, on how to design for pleasure.

(b) Currently, many research workers have and are taking part in a research programme to measure the performance of thermal plant. Yet apart from re-affiring that hot air still rises, the most important factor discovered to date is that 'non assessibility' appears to be the fundamental criteria in plant design. The fact is that how heating and/or cooling systems work is not known in anything but the crudest detail. There are too many partial measurements, too many approximations, and too many unmeasurable systems. Furthermore, the indications are that systems which are designed to work at optimum efficiency at the design conditions are for the majority of their life when design conditions are very seldom met, operating at anything up to 40% inefficiently.

This then is the situation that has been reached as the result of the first Research and Development Cycle.

Current Research

In December 1970 it was concluded that the previous work was 'definitive' enough to encourage further detailed research and application of the principles [14] outlined above. For the feedback results had suggested that there were two ideas that could be developed, for the Designer, namely:

(a) Variety reducing constraints - the law of diminishing returns.

(b) 'Positive' degrees of freedom.

To this end, a range of standard structural panels of different combinations of materials in construction was first investigated by computer simulation to demonstrate the effect of choice of materials and differing glass and solid ratios. An example of the results, is given in Fig 5, translated into terms of 'heat loss' in Fig 6. From this study a limited number of materials in construction, economic in thermal, acoustic and constructional terms emerged, for example, a heavyweight panel of U-value 0·5W/m^2 deg C containing 20% 6mm glass in a cedar wooden frame. In addition, economic 'break points' at which the environmental performance of the roof and floor rather than that of the walls should be considered were examined.

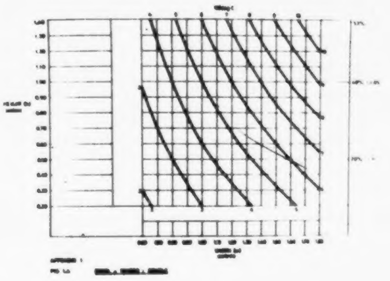


Figure 5

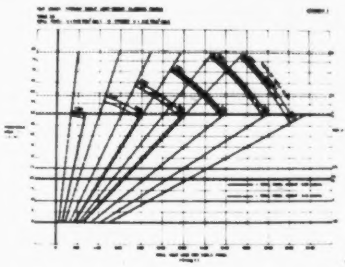


Figure 6

Using these results a series of complete buildings of simple rectangular plane form were next analysed. The following parameters were varied: width/length ratio; number of storeys; total floor area; floor to floor height; heat transfer coefficient of roof and floor; window wall ratio. An analysis showing the effect of these variables on heat loss, capital, and running costs was derived. Fig 7 gives an example of the results.

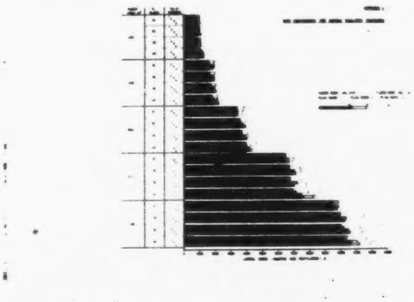


Figure 7

The similarity of sections of these results, and, therefore, perhaps the freedom of designing for the scene thermal consequences, for example, over a range of storey heights, plan shapes, areas of glass etc should be considered. The suggestion that a number of spaces of differing shapes and sizes, have the same 'thermal capability' present itself. Comparisons with Musgrove's work [42] on space classifications are irresistible.

Using this process a 2 Form Entry Junior School has been designed (Fig 8) and is in the process of being built [43].

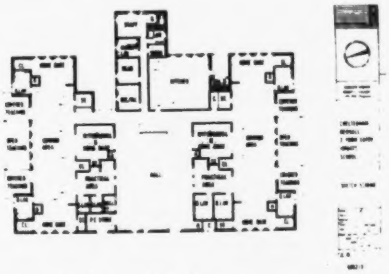


Figure 8

The Research and Development Cycle is into its second time around.

What then for the future? The plea, therefore, must be for simplicity in design and control. For Design based on the simple principles which are often forgotten. For Design based on the probabilistic view. Finally, for Design that is measurable. Then we must build more, monitor and wait.

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NEW METHODS AND RESEARCH IN QUALITATIVE EVALUATION OF ARCHITECTURAL ACOUSTICS

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Abstract

This paper describes an experiment in the factor analysis of subjective responses to classroom acoustics. The experiment is placed in the context of, and compared with, other recent studies in subjective responses of room acoustics.

It seems to be generally agreed that where pure tones heard through a pair of earphones is concerned, the main subjective attributes are loudness (in sones) and pitch (in mels). However, most architects and acousticians are more concerned with the design of acoustic environments in complex live spaces (concert halls, theaters, lecture halls, classrooms, etc.) where the nature of the subjective response is not so well understood. There is a lack of knowledge as to what constitutes "good" acoustics, and what the physical correlates are so that the design of acoustic quality may be predicted. The need to conduct studies of subjective responses to acoustics is that people do not perceive physical stimuli per se, but rather the perception and the response to the percept depend on many such factors as experience, adaptation,and other personal attributes. In other words, it is not possible at the moment to design from physical attributes towards predicted subjective responses (human behaviors). Rather, in acoustics, as in many other fields at present, we have to analyze the human response, find correlations with physical attributes and develop a predictive model. One illustration of the dangers of blindly following physical parameters.

It had long been thought that the relationship between reverberation time (RT) and room volume was the single most important physical parameter of good acoustics. A number of acousticians have produced curves of optimum RT against room volume.

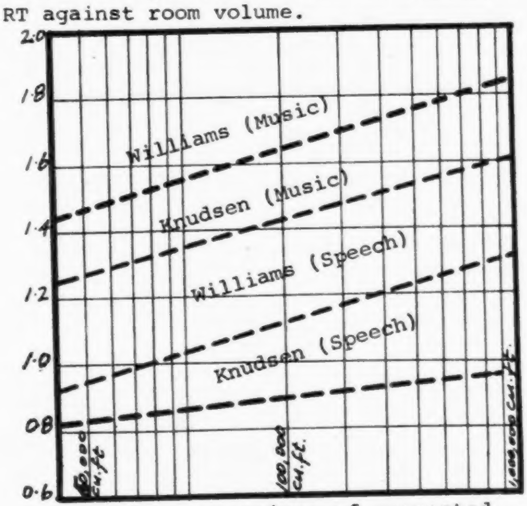


Fig. 1 A comparison of suggested optimum RT's.

For some considerable time the only criteria the architect had in designing a hall or auditorium were the required room shape, the required RT/volume ratio, and the number of absorption units (sabines) needed to produce the desired RT. Sabine had defined RT as the time taken for a 60 dB drop in sound after the initial sound ceases. However, Atal, Schroeder and Sessler (1) conducted an experiment which showed that subjective RT is more closely correlated with the decay over the first .16 sec., rather than a 60 dB decay. In addition, the work of Járfas and Tarnóczy (2) have shown (as have numerous other investigators) the discrepancy between subjective and physical RT.

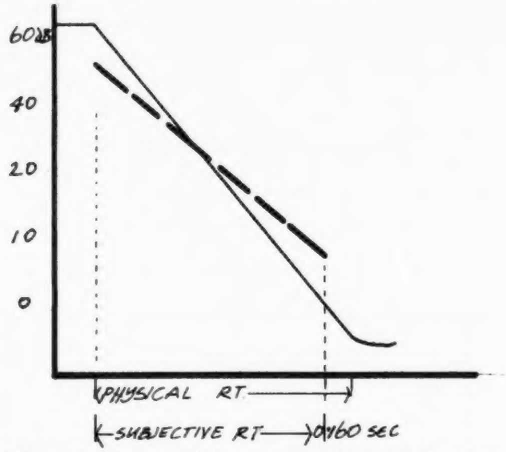


Fig. 2 A possible comparison of subjective + objective RT's.

If this is so, first find the physical correlates of subjective RT, then designers can begin to predict the effect of room RT upon the hearer.

One of the first attempts to categorize subjective attributes of room acoustics was published by Beranek in Music, Acoustics and Architecture, published in 1962 (3). Subsequent studies have largely been based on his groundwork.

Beranek

Beranek studied 47 concert halls and from his study he produced a list of 18 subjective variables which he felt to be correlated with physical ones.

1. Intimacy-depends on initial time delay gap, i.e., the time interval between the direct sound and the first reflection, so that a large hall can give a feeling of acoustical intimacy if reflectors are placed so as to give a short initial time delay gap.
2. Liveness-effect produced by a long RT at high and middle frequencies, i.e., above 500 Hz.
3. Warmth-effect produced by a long RT at low frequencies, (below 500 Hz).
4. Loudness of direct sound.
5. Loudness of reverberant sound.
6. Definition or clarity. Beranek distinguishes between horizontal definition, the degree to which sounds which follow one another stand apart, and vertical definition, the degree to which sounds which occur simultaneously are heard separately. Definition is related to liveness, warmth, loudness of direct sound and loudness of reverberant sound.
7. Brilliance-bright, clear, singing tone, rich in harmonies. Depends on the relative prominence of high frequencies and slowness of their decay, and is affected by the initial time delay gap, the ratio of the high frequency RT to the middle frequency RT. Brilliance is related to liveness, clarity and intimacy.
8. Diffusion-the experience of the reverberant sound seeming to arrive from all directions at once at the same intensity.
9. Balance-the correct relative loudness of different parts of the orchestra.
10. Blend-hearing the orchestra as a whole rather than its parts separately.
11. Ensemble-the performer's ability to play in unison, depends on their ability to hear each other.
12. Immediacy of response-experienced by the musicians if the hall seems to respond immediately to a note; it depends on the first reflections arriving at the performer's ear. Related to intimacy, liveness, diffusion, ensemble and echo.
13. Texture-subjective impression produced by the pattern of sound reflected arriving at the listeners' ears.

14. Freedom from echo.
15. Freedom from noise.
16. Dynamic range-spread of sound level over which music can be heard. The lowest level is determined by the background noise produced by the audience and any external noise. The highest level is determined by the amount of sound which the players can produce and the acoustical characteristics of the hall. Related to the loudness of direct sound, loudness of reverberant sound and freedom from noise.
17. Tonal quality-can be spoiled by abnormal sound absorption leading to loss of certain frequency bands, or ringing of metal bars in front of the organ, or by flutter echo between two parallel reflecting surfaces.
18. Uniformity-throughout the hall.

Whilst some of the 18 variables are only descriptive, others, Beranek maintains, are subjective variables which are correlated with physical parameters of the sound and to properties of the hall. Beranek arrives at these correlations intuitively, based on past experience rather than experimental study.

Beranek next sets up a weighted scale designed to show which of the 18 variables are the most important in giving an overall impression of the acoustical quality of a given hall.

In order to do this, the 18 attributes are divided into positive and negative attributes. The concert halls visited throughout the world were rated for acoustical excellence on a 6-point scale. The object was to weight each of the attributes in such a way that the total score for each hall would correspond to the correct total rating (A+, A, B+, etc.) for the hall.

The final weighting for the positive attributes are as follows. According to the subjective evaluation, this weighted scale (plus the corrections of the negative attributes) will predict the response to an auditorium acoustic.

POSITIVE	NEGATIVE
intimacy	echo
liveness	noise
warmth	distortion
loudness of d.s.	non-uniformity
loudness of r.s.	
balance and blend	
diffusion	
ensemble	

Fig.3 Beranek's positive and negative attributes.

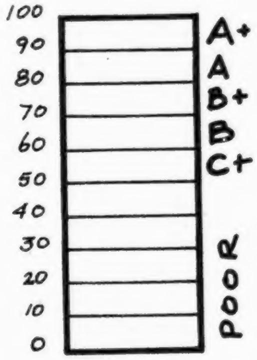


Fig. 4 Beranek's scale of acoustic excellence.

An attempt was also made to correlate the hall categories with physical variables, RT, volume and initial time delay gap.

In their paper on subjective acoustic

ATTRIBUTE	MAX. POINTS
intimacy	40
liveness	15
warmth	15
loudness of d. s.	10
loudness of r. s.	6
balance and blend	6
diffusion	4
ensemble	4
	100

Fig. 5 Beranke's weighting of attributes.

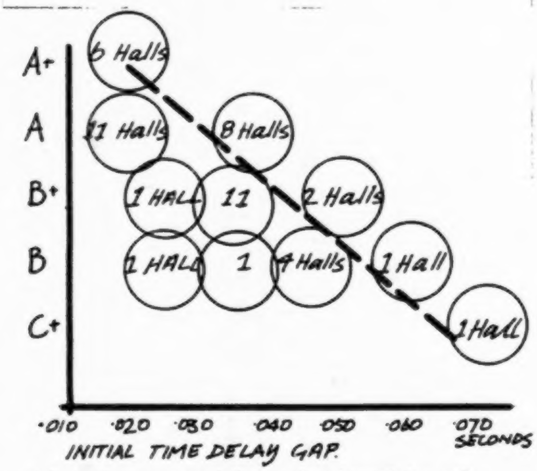


Fig. 6 Beranek's relationship of hall excellence to i. t. d. g.

evaluation, Hawkes and Douglas point to two weaknesses in Beranek's system. Firstly, it is assumed that all the attributes are linearly additive:

> "This seems intuitively not to be so, as it would suggest, for example, that an echo is less distracting in a hall with a higher intimacy rating, or that external noise will have less effect, the better the balance. Even if these different variables do interact, it is not likely that they do so in such a simple way." (4)

The second weakness is the assumption that the relationship between categories and initial time delay gap is a linear one. Hawkes and Douglas point out that the relationship could just as well not be linear, and that, for example, below a .03 sec. initial time delay gap, there is a leveling off in acoustical quality category.

Somerville

Somerville (5, 6, 7) developed an empirical acoustic criterion, in which he found that acoustic quality depends upon 3 variables:

> Firstly, the mean RT of a space, averaged over all audible frequencies (Tm).
> Secondly, the variability of the RT with frequency (R) such that if "r" is the mean divergence from Tm,
> $R = -20 \log_{10} 10r$
> Thirdly, the variability in the decay of a single tone (D) considered for frequencies of 50, 100, 200, 300, 1000, 1200, 1300, 1600, 2000 Hz. A straight line is drawn through the decay curve for each frequency, such that equal areas of the curve lie either side of the line. The total area is calculated and $D_1 = S/OB$ is determined.
> $D = D_1$

With these variables, Somerville was able to predict spaces (studios) with good acoustics from the following graph. This correlation between D, R and Tm was also tried out on concert halls and it was again found the concert halls rated good fell into the same correlation band.

Marshall

A number of investigators have been interested in the cross sectional area of concert halls, and therefore with the reflection pattern and especially with the importance of first reflections.

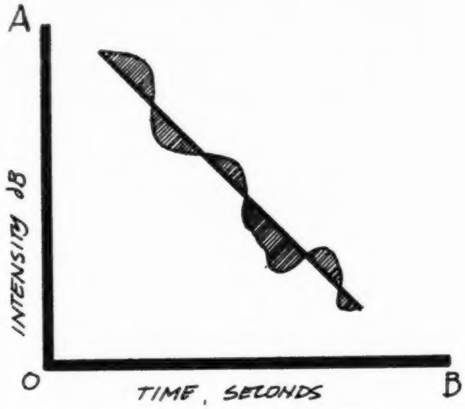


Fig. 8 Sommerville's study.

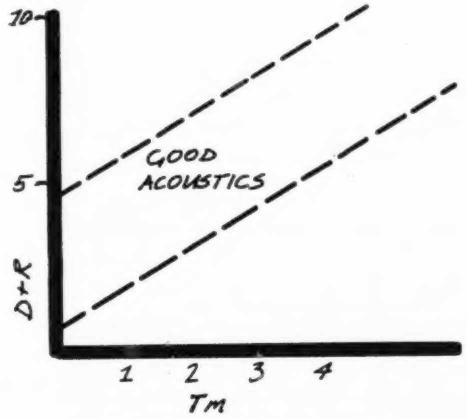


Fig. 9 Sommerville's study.

Marshall (8) attempts to correlate acoustic quality with "spatial responsiveness," which, Marshall says, is responsible for such attributes as presence, reverberance, intimacy and so on. Spatial responsiveness is to be found in the older, more traditional halls with high ceilings and narrow cross sections, in contrast to the totally different cross section and plan of the modern halls which in an attempt to pack in larger and larger audiences have a totally different plan shape.

Marshall says that in the traditional tall, narrow hall, the first reflections to arrive at the listener are from the side walls rather than from the ceiling; whereas, in the new, fan-shaped halls, the first reflections are from the ceiling thus masking the following side-wall reflections. Spatial responsiveness, then, is correlated with unmasked lateral reflections arriving soon after the direct sound.

Barron

Barron (9) conducted experiments with simulated reflections in an anechoic chamber to study the importance of early reflections in a concert hall. His most important finding was the effect of spacial impression which he identified as the predominant subjective effect. The study showed that this can be produced by reflection delays between .01 and .08 sec. in lateral rather than ceiling reflections.

The degree of spatial impression is probably related to the ratio of lateral to non-lateral sound arriving within .08 sec. of the direct sound.

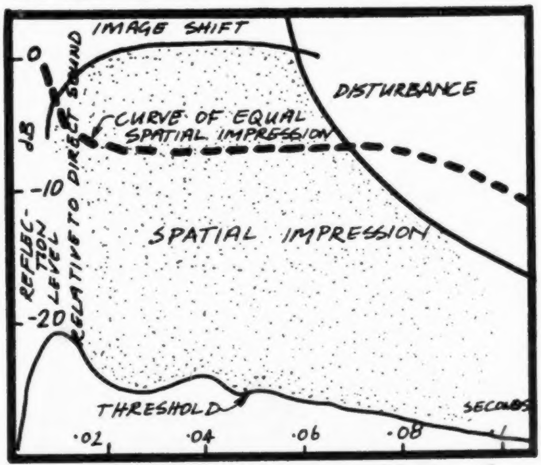


Fig. 10 Barron, subjective effects of a single side reflection.

Watters, Beranek and Schultz

The authors state (10) that their aim has been to scale the more important subjective factors of the effect of the acoustic character of halls upon speech and music. To them, the important parameters of sound in a live hall are,

apparent direction
apparent duration
loudness
pitch
timbre.

Using these 5 basic attributes, the authors show that there are 11 acoustic factors dependent upon them.

"is substantially the inverse of reverberance when the vocal sound is heard alone, and substantially the same as 'sectional balance' when the voice competes with other instruments."

Both Hawkes and Douglas and Payne have shown from empirical experimentation that clarity as a factor appears to be entirely independent from reverberation and sectional balance (evenness).

DIMENSIONS OF SOUND	BASICS				
	Loudness	Pitch	Timbre	Duration	Angular extent
Overall loudness	X				
Sectional balance	X				
Clarity	X				
Quiet	X				
Bassiness	X	X			
Brilliance	X	X			

DIMENSIONS OF SOUND	BASICS				
	Loudness	Pitch	Timbre	Duration	Angular extent
Echo level	X			X	
Distortion	X		X		
Terminal reverberance				X	
Running reverberance			X		
Envelopment					X

Fig. 11

The 11 attributes are defined thus.

1. Overall loudness-that aspect of auditory sensation in terms of which the overall sound may be ordered on a scale running from soft to loud.
2. Sectional balance-the uniformity of loudness of the sounds from the various sections of a performing group. (This factor seems to equal "evenness" and "balance and blend" factors of Hawkes and Douglas.)
3. Clarity of vocal sounds-the sensation of effortless intelligibility of vocal sounds. The authors further state that "clarity"

4. Quiet-the condition of unawareness of unwanted sounds.

All these 4 factors are based on loudness.

5. Bassiness-the relative loudness of low pitched sounds.
6. Brilliance-the relative loudness of high pitched sounds.

Both of these factors are based on loudness and pitch.

7. Echo-the loudness of apparent singularities in the delayed sound field, relative to the sound onto which they intrude.

Echo is based on loudness and duration.

8. Distortion-the relative loudness of undesirable components that modify the tonal quality.
9. Reverberance of terminal sounds-the apparent RT of terminal sounds.
10. Running reverberance-the sensations of "non-anechoicness" (i.e., reverberance) of continuous sounds.
11. Envelopment or source spread-the apparent angular extent of arrival directions of the sound field.

In addition to the above 11 factors the authors add another 2 which are unrelated to their 5 fundamental parameters.

12. Bloom-the sensation, associated with the onset of sound, of gradual growth in loudness.
13. Sheen-the quality, primarily of the violin tone, of subjective smoothness.

The main weaknesses of this study are firstly, they are based on intuition and are in part contradicted by 3 separate studies carried out by Hawkes and Douglas and Payne using a wide variety of spaces and sound sources.

Secondly, many of the definitions are tautological and therefore those attributes remain undefined labels.

Thirdly, it seems to destroy the intention of defining the "more important dimensions" of acoustics when particular instrumental or voice qualities have to be used (as in factor 13).

Finally, it seems confusing to attempt to categorize the factors as being dependent upon 5 fundamental attributes, only to find that 2 attributes have to be added as an addendum.

Hawkes and Douglas' Study

Hawkes and Douglas (4) started out by studying the effect of an assisted resonance system in the Royal Festival Hall, London. Sixteen rating scales were used and the results were factor analyzed. Five factors were obtained.

Factor	Associated Scales
1. Resonance	Resonant
	Reverberant
	Live
	Responsive
	Warm
2. Definition	Good definition
	Clear
3. Proximity	Close
	Intimate
	Responsive
	Good
4. Balance + Blend	Balanced
	Blended
	Even
5. Brilliance	Brilliant
	Live
	Warm
	Liked
	Large dynamic range

Fig. 12 Hawkes + Douglas' first study.

What this means is that the subjects during this experiment were being influenced by 5 subjective concepts. As the authors say,

> "This shows that concert hall acoustics cannot be considered, as Marshall suggests, in terms of one subjective effect with one physical cause, nor as Somerville suggests, of one subjective effect dependent on a relationship between a set of physical variables."

The second study carried out by Hawkes and Douglas was divided into two parts in which firstly, subjective ratings were compared between different positions in the same hall and secondly, the ratings were compared between 4 different concert halls.

In the first part, 23 positions in the Royal Festival Hall were selected throughout the auditorium and subjects sitting in these seats were asked to rate the acoustic quality on 16 scales. Factor analysis of the results produced 4 factors. Two interesting points arise from the results. Firstly, that Beranek's definition of "brilliance" as the relative prominence of treble and the slowness of its decay and its relationship to clarity seem to be supported. Secondly, the factor means for the 23 positions throughout the hall showed a considerable variance in the mean score for reverberance. Now since the RT is fairly constant throughout the hall, the results would indicate that reverberance is more complex than a straightforward correlate of RT as had often been thought in the past.

In the second part of the experiment, 4 positions were chosen in each of 4 concert halls so as to study the possible effect of size and shape on the subjective response to acoustics. This time 6 factors were obtained.

Factor	Associated Scales
1. Definition	Good definition Clear Brilliant Responsive
2. Reverberance	Reverberant Resonant
3. Balance and Blend	Blended Balanced Good Even
4. Proximity	Close Warm Responsive Live Liked

Fig. 13 Data from many positions in one hall.

As a result of their studies, Hawkes and Douglas conclude that,

> "the effect of 'evenness' is related to the distance from, and the alignment with, the orchestra, that the effect of 'intimacy' is related to proximity to the orchestra, to a short initial time delay gap and to the shape of the hall, such that 'intimacy' is likely to be higher in a narrow, high ceilinged hall than in a wide, low ceilinged one, and that 'brilliance' is related to a long RT at high frequencies."

Factor	Associated Scales
1. Reverberance	Reverberant Resonant Responsive Large dynamic range
2. Evenness	Even Balanced Blended Clear Good definition
3. Intimacy	Intimate Close
4. Definition	Good definition Clear Large dynamic range
5. Enjoyment	Liked Good
6. Brilliance	Brilliant Live Warm Responsive

Fig. 14 Data from 4 halls.

It should be pointed out, that a limitation of these experiments, lies in the fact that only 16 rating scales were used, the same in each experiment, and that the scales were based on the suggestions of Beranek. The use of more varied, or at least additional rating scales might have produced other factors, not associated with the concepts of Beranek.

So far I have been dealing with studies which investigated the acoustics of concert halls and music. I wish to turn now to studies of rooms and halls in which speech is used. The basic information on speech articulation as affected by noise levels, RT in auditoria of various sizes and loudness of speech is given by Knudsen and Harris (11). What is interesting is that all the

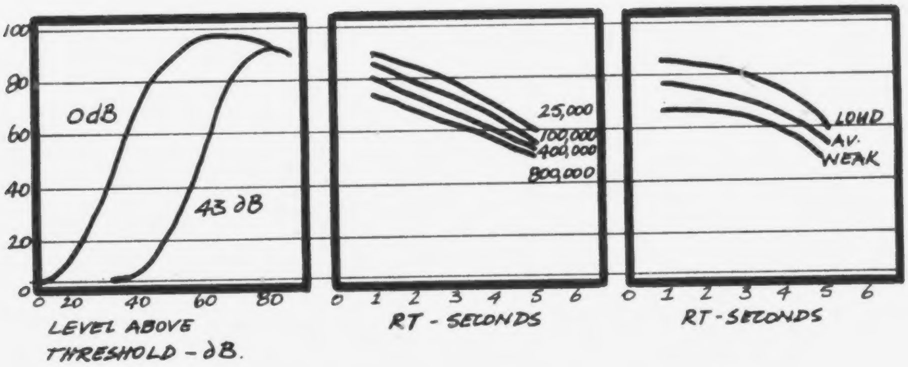


Fig. 15 Basic data on speech intelligibility (Knudsen).

data starts from a reference RT of 1 second, whereas Bruce and Watters (12) and other present day investigators seem to favor the first few reflections within milliseconds as being crucial.

Nickson and Munce

In their study, Nickson and Munce (13, 14, 15) stress the importance of the RT of halls designed for speech, in particular they stress the importance of ensuring that reflections arrive at each listener within .035 sec. of the direct sound.

The authors also studied the relationship of Articulation Index (AI) and RT and produced a subjective rating for AI.

Bruce and Watters

In their study of AI, Bruce and Watters (12) state that in the case of speech heard in theaters or lecture rooms there are 3 objective variables:

speech levels
background noise levels
reverberation.

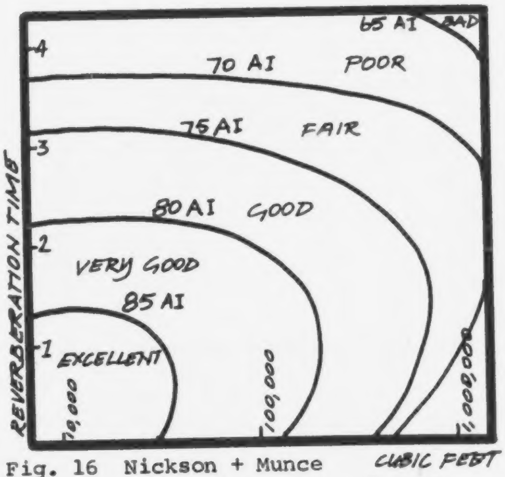


Fig. 16 Nickson + Munce subjective rating for AI.

The subjective response to speech quality in a hall is a function of these physical variables and the ease with which the speech is understood. However, they state that RT is the most important of the variables. Also, it seems that direct sound and early reflections have a considerable effect on the AI, whereas, longer RT's, as Lochner and Burger (16) pointed out, need compensation. The use of AI alone is felt not to correlate with the ease of speech communication or clarity.

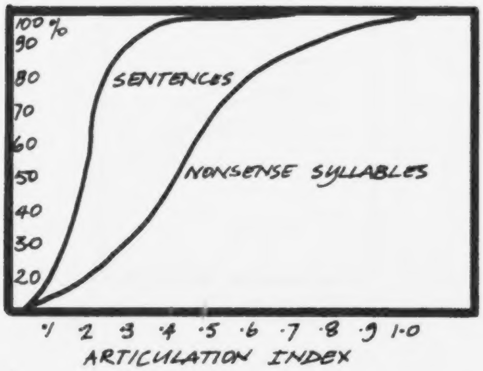


Fig. 17 Relationship between percent intelligibility and AI.

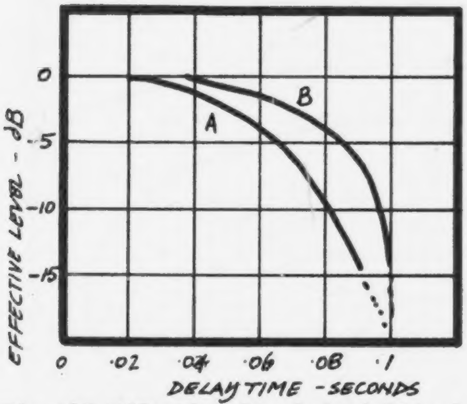


Fig. 18 Effective level (weighting) of delayed sound components for 0dB (A) and -5dB (B) reflections.

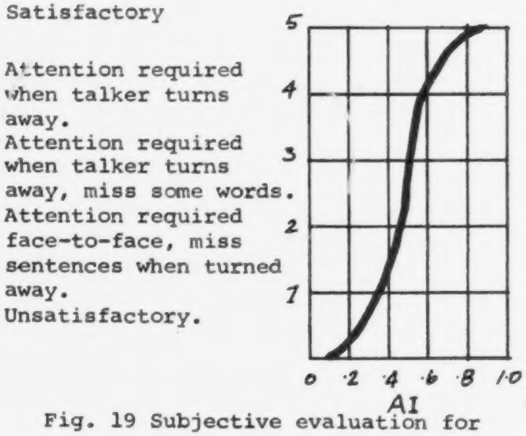


Fig. 19 Subjective evaluation for drama vs. AI.

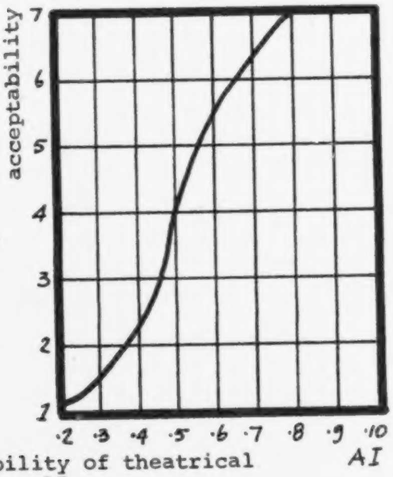
It seems that a new criterion must be found for the easy understanding of normally delivered speech.

Bruce and Watters have developed a subjective evaluation of speech clarity and AI for dramatic speech in which they used simulated hall acoustics using electronic equipment to reproduce reverberations. Their experiment showed that with an AI of 0.3, the subjective response was unsatisfactory, whereas, in the original AI weighting of Lochner and Burger an AI of 0.3 was seen to have a 90 to 100% intelligibility. This discrepancy is explained firstly, by the fact that earlier experiments were concerned with intelligibility, whereas listeners in rooms were judging acceptibility. Secondly, the traditional laboratory experiments used phonetically balanced word lists artificially enunciated. Subjective responses in lecture halls or theaters are concerned with normal or dramatic speech which is fast and has a variable intensity. Also the speaker's head direction varies and this has an effect upon the intelligibility of speech. Thirdly, earlier experiments had been carried out in artificial surroundings, not at all similar to the acoustic ambience to a live hall situation.

It is interesting to note that subjects found an AI of 0.95 to be more acceptable than an AI of 1.00, and the authors hypothesize that this is caused by a preference of the listeners for the room characteristics to be audible as well as for the speech to be clear. Which raises the question that if this is so, what are the characteristics of the room acoustics that are more important than "perfect" intelligibility?

I wish to turn now to studies directly

Fig. 20



Acceptability of theatrical speech vs. AI.

concerned with the acoustics of classrooms, though all of the above studies are applicable to the classroom situation. If little research has been carried out into subjective responses to concert hall acoustics, even less attention has been paid to this aspect of classrooms. Yet, whereas the design and building of concert halls is indeed expensive and therefore should be studied in depth to ensure success, the construction of classrooms and lecture theaters is far more widespread probably (because of its formative influence) of far greater fundamental importance.

Tolk and Peutz

In this study (17) the AI was measured in 9 school classrooms and the relationship of AI loss to RT computed. The authors then measured the RT of 50 classrooms in 18 elementary schools (presumably in the Netherlands), categorizing the rooms as old (built before 1940) and new (built after 1945). Computing the average AI loss for these 50 classrooms, they found it to be 40%!

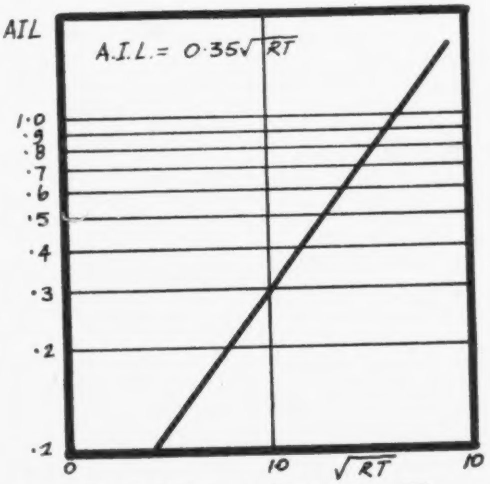


Fig. 21 Maximum AI loss vs. RT in classrooms.

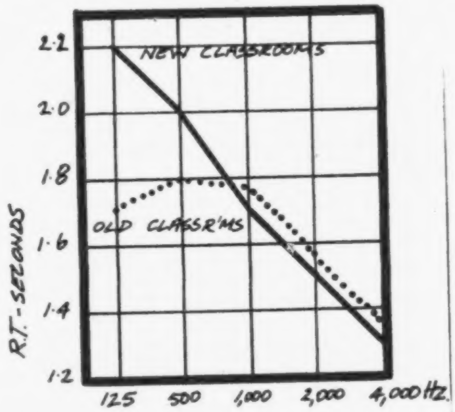


Fig. 22 Average RT vs. frequency for 50 classrooms.

Tolk and Peutz also measured the background noise in the 50 classrooms and found the average background noise level to be 40 phons (i.e., approximately NC 35). The maximum NR values between classrooms was in the range 20-30 dB.

Fitzroy and Reid

First published in 1961 this seems to be the major study of American schools from the point of view of their acoustic environments. As the authors state (18) the objective of their study was,

"to determine the minimum acoustical

> separation that is necessary to allow a group or an individual to work effectively. In how noisy an environment can a teacher and a group of students work, communicate, and study without extraneous, unwanted sounds interfering? What kind of sounds are objectionable and what is the limit of tolerable sound levels? In short, what are all the criteria for the design of an acoustical environment which can effectively accommodate a range of activities?"

Thirty-seven classrooms in 4 schools were evaluated. Potentially the most important aspect of the study was a teacher opinion survey, which sought subjective responses to the classrooms. However, there are 3 drawbacks to the data obtained. Firstly, the opinion rating scale, rather than being a normally balanced 5-point scale was a biased scale:

Excellent
Good
Satisfactory
Acceptable
Not Acceptable

That is, there were 4 acceptable points and only 1 non-acceptable point. This, unfortunately, makes the authors' conclusions undependable.

Secondly, having collected the data, there is no real attempt at computing correlations between the subjective and the physical data. In the report, all the data is reduced to overall means.

Thirdly, as Mr. Mikeska points out in a note in the study itself,

> "In general, I suspect that many of the teachers' and administrators' reactions are strongly influenced by factors other than acoustic, such as lighting, room arrangement and general adequacy of the facilities for the teaching needs involved."

Amongst the data gathered are RT's, AI's, NR's and noise levels. Unfortunately, the AI studied, is AI *between* rooms rather than *within* rooms, so it is not possible to make correlations of AI with room RT, or room AI with room satisfaction.

The authors conclude that there are 6 important variables to classroom acoustics.

1. Reverberation time. The authors state that "where the room is near the speech optimum, both speech and listening is comfortable without effort necessary on the part of speaker or listener." But no evidence is given to support this statement.
2. Intruding noise should be of a general character, without easily identifiable components.
3. Very low AI between rooms.
4. An acoustically absorptive floor covering to reduce within-room noise.
5. Noise reduction between teaching areas, but this is not too important "but in view of the first 4 variables the actual amount of noise reduction /is/ . . . not too important."
6. The human factor.

The report is useful in that it raises more questions than it answers. In other words, it brings to the fore a number of aspects of classroom acoustics that require further study.

1. A more comprehensive and better planned survey of teachers and students is required, possibly (but not exclusively) using semantic differentials.
2. Considering the work of others described in this present paper, a study of the correlation of RT and AI within rooms might be attempted.
3. Looking at the highest positive scores in the survey that was carried out:

	NR	dB	SI	AI	RT	Optimum RT
70% Excellent	24	64	41	.01	1.04	.65
67% Excellent	32	65	47	.01	.63	.73
100% Good	8	80	50	.01	.73	.73
82% Good	27	61	35	.07	1.05	.68
77% Good	23	63	47	.01	.57	.67

we find: an NR range of 23-32
dB range of 61-80
SI range of 35-58
AI range of .01-.07
RT range of .57-1.04

and variances from the optimum RT of .39, .10, 0, .10, .37 sec.

It has to be said that despite the fact of the very high subjective ratings, the physical correlates are average for the study, with a fairly wide range. There is still much need for more investigation.

4. The authors' sixth variable of "human factor." This is given the least consideration in the study, yet looking at the results, it seems as though it should have been given the highest consideration.

Center for Architecture Research

This is a report (19) which attempts "to gather and organize information regarding acoustics in schools as planning guidance for planners and administrators."

In the section on Acoustics within educational spaces the report states that,

> "In its simplest terms acoustics in facilities design is concerned with 2 prime objectives; (1) the provision of a satisfactory acoustical environment by eliminating unwanted sound or by raising barriers to unwanted sounds originating outside the space and (2) providing good hearing conditions within a space by controlling the direction, impact and duration of sound waves." (my underlining)

Earlier the report has defined "quality of sound in a room" as what happens to the various frequencies in their paths of travel from the source to the listener, and what happens is threefold:

1. Selective absorption by air.
2. Selective absorption by surfaces.
3. Effect of the resonant characteristics of the room.

Other than reiterating this in greater detail the report never details exactly what constitutes "satisfactory acoustical environment" and "good hearing conditions," yet the report goes on at great length describing how these conditions may be achieved.

In describing subjective responses to acoustics for music in schoolrooms the report bases the subjective variables on a list drawn from Acoustics in Architecture by Doelle, which are in turn a shortened (9 attributes) version of Beranek, which brings us full circle.

The Present Study

An experiment was carried out in the University of Maryland to identify the major factors influencing the subjective response to acoustic quality of classrooms. Factor analysis of semantic rating scales was used. Three classrooms were chosen for the study because they represented a cross section of typical classrooms in use on campus.

Room 1, BPA 07: medium, old, flat floored. Basement, 13 years old. 50' x 20' x 12'. Rectangular in shape. Seats 75 total, but 45 present during sampling. Students seated on conventional wooden tablet-arm chairs on a flat vinyl asbestos floor. At the front of the room is a large blackboard (wall to wall). The remainder of the wall is finished with acoustic tile. Left wall has glazing while the remaining walls and ceiling are surfaced with acoustic tile.

Room 2, PHYS 175: Physics seminar room. Small, new, flat floored. On ground floor. 20' x 30' x 12' high. Total seating capacity of 25. (12 present during sampling.) Has wooden tablet-arm chairs on flat concrete slab floor which is of same construction as the ceiling. A 20' x 5' blackboard is mounted on a concrete block wall as is the construction of the remaining walls. The only opening is the entrance door. The corners of the room are surfaced with 5 or 6 acoustical tiles.

Room 3, COMPSCI 204: medium, old, sloped floor. On second floor. 35' x 70' x 20'. Seating capacity of 70 students of which 50 were present during sampling. Has fixed wooden tablet-arm chairs. The seating is placed on 8 room-width stairs, but the first 10 feet of the floor is flat with vinyl asbestos tiles. A 20' x 4' blackboard is mounted on a painted concrete wall. The right wall has a door, the left wall has four 3' x 8' high windows and are both of concrete block construction as is the rear wall. Plastered ceiling.

The rating scales comprised 28 pairs of bi-polar semantic scales, initially based on Beranek's list, but expanded beyond his original 18 variables. The students, untrained in acoustics, who rated the rooms were distributed throughout all parts of each classroom, the number of students rating each room being:

BPA 07 - 39 students
PHYS 175 - 29 students
COMPSCI 204 - 30 students

The following results were obtained.

BPA 07: 5 factors

Factor 1: Distinctness

.834	Distinct
.804	Sharp
.786	Good
.712	Balanced
.693	Clear

Factor 2: Publicness

.700	Public
.693	Resonant
.537	Reverberant
.514	Comfortable

Factor 3: Enjoyment

.850	Enjoyed
.682	Close
.652	Live
.546	Warm

Factor 4: Softness

.730	Soft
.593	Even
.558	Quiet

Factor 5: Warmth

.516	Warm

(It should be questioned whether the "warmth" - despite instructions to rate only the acoustic environment - refers to thermal conditions, though Beranek has "warmth" as an attribute.)

PHYS 175: 7 factors

Factor 1: Balance

.803	Balance
.801	Good definition
.742	Resonant
.742	Responsive
.714	Clear
.715	Blended

Factor 2: Brilliance

.902	Brilliant
.857	Full
.784	Close
.722	Warm
.648	Distinct
.566	Vibrant

Factor 3: Softness

.813	Soft
.677	Direct
.675	Even

Factor 4: Noisiness

.866	Low external noise
.782	Low background noise

Factor 5: Unreverberance

.698	Unreverberant
.681	Enjoyed
.585	Wanted sounds

Factor 6: Intimateness

.766	Intimate
.607	Small dynamic range

Factor 7: Pleasantness

.780	Pleasant room
.580	Good
.522	Comfortable

COMPSCI 204: 7 factors

Factor 1: Vibrance

.852	Vibrant
.772	Balanced
.739	Close
.715	Large dynamic range

Factor 2: Noisiness

.798	Low external noise
.702	Low background noise

Factor 3: Definition

.833	Good definition
.654	Brilliant
.610	Intimate
.584	Unreverberant
.552	Clear

Factor 4: Sharpness

.714	Sharp
.695	Wanted sound
.662	Good
.621	Distinct
.561	Direct

Factor 5: Comfort

.843	Comfortable
.774	Enjoyed
.618	Even
.507	Direct

Factor 6: Liveness

.730	Live
.517	Distinct

Factor 7: Warmth

.845	Warm

Factors obtained when the 3 rooms were analyzed together.

Factor 1: Definition

.667	Good definition
.654	Responsive
.625	Clear
.585	Loud
.566	Live
.535	Good

Factor 2: Softness

.685	Soft
.599	Direct
.584	Even

Factor 3: Fullness

.748	Full
.690	Close
.590	Large dynamic range
.580	Brilliant

Factor 4: Noisiness

.730	Low background noise
.713	Low external noise
.560	Wanted sound

Factor 5: Reverberance

.672	Reverberant

Factor 6: Enjoyment

.597	Enjoyed

Factor 7: Balance

.529	Balanced
.527	Vibrant

A comparison of all the data is as follows. See following page Fig. 23.

Finally, it may be worth displaying these factors along with the factors proposed by Hawkes and Douglas, Beranek and Watters, Beranek and Schultz. It should be borne in mind that some factors were derived in concert halls, though Watters, Beranek and Schultz claim that their factors apply equally to theaters (speech). See following page Fig. 24.

Several things are worth noting. Firstly, the degree of homogeneity with the findings of Hawkes and Douglas, even though a much expanded scaling list was used.

Secondly, a great weakness, in that all the semantic descriptors are limited in scope and all are derived initially from the original list compiled by Beranek. This in itself is sufficient to ensure a degree of homogeneity amongst all investigators.

However, thirdly, despite the fact that as much as 28 pairs of words were used

BPA 07	PHYS 175	COMPSCI 204	All Classrooms
Distinctness			
Publicness			
Enjoyment			Enjoyment
Softness	Softness		Softness
Warmth		Warmth	
	Balance		Balance
	Brilliance		
	Noisiness	Noisiness	Noisiness
	Unreverberance		
	Intimateness		
	Pleasantness		
		Vibrance	
		Definition	Definition
		Sharpness	
		Comfort	
		Liveliness	
			Fullness
			Reverberance

Fig. 23

All Classrooms	Hawkes and Douglas 1	Hawkes and Douglas 2	Beranek	Watters, Beranek and Schultz
Enjoyment				
Softness				
Balance	Balance	Balance	Balance	Balance
Noisiness			Noisiness	Noisiness (quiet)
Reverberance	(Resonance?)	Reverberance	Loudness of reverberant sound	Reverberance
Definition	Definition	Definition	Definition	
Fullness				
	Brilliance		Brilliance	Brilliance
	Resonance			
	Closeness	Closeness		
			Warmth	
			Intimacy	
			Liveness	
			Loudness of direct sound	
			Diffusion	
			Blend	
			Ensemble	
			Immediacy of response	
			Texture	
			Freedom from echo	Echo
			Dynamic range	
			Tonal quality	
			Uniformity	
				Clarity
				Spread
				Loudness
				Bloom
				Bassiness
				Sheen
				Distortion
				Running reverberance

Fig. 24

(in the present study) it seems that as few as 5 to 7 factors are sufficient to initially describe the subjective response to hall acoustics (but see (20)), which would seem to indicate that a number of Beranek's 18 and Watters' 13 variables might be redundant.

Enough has been shown, though, to suggest that when designing, for example, classrooms, attention should be paid not only to the quietness of the room, the NR of the walls, the RT and the SI, but also to the balance of the sound, the intimateness and the evenness and softness of the sound.

Conclusions

The field of subjective evaluation of room acoustics is new, and so far very little is known and less is understood. The most important aspect of any future work must be to broaden the scope of the work and of the descriptors used. Therefore a systematic compilation of a lexicon of acoustic descriptors is needed, followed by an experimental examination of each of the descriptors in order to systematically arrive, by empirical study, at a true condensed list of descriptors equally covering the whole range of subjective acoustic experience.

There is, furthermore, a pressing need to find physical correlations to the subjective factors, and the next stage of this study must be to correlate physical measurements with the factors. At the same time a wider range of rooms need to be studied, lecture halls, classrooms, seminar rooms, dinner theaters, theater clubs, as well as the large concert auditoria, so that the possibility of obtaining universal acoustic factors is studied.

But most important of all, the new awareness of the complex factors affecting the subjective response, and the acquisition of physical correlates, must lead directly into the design of new rooms (classrooms) so that the iterative research process becomes a

study → building → study

process rather than a

study → evaluation → study

or

study → conference paper → study

process.

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THE BEGINNINGS OF A THEORY OF ENVIRONMENTAL CONTROL

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Abstract

There is still no new paradigm or theory of environmental control to guide the architect in the use of physical form to maintain the various types of sensible energy within the human comfort range. This paper does not propose such a theory, but it does sketch out some of the factors which seem to point to the beginning.

The Dilemma

It may come as a bit of a shock to most architects, but the environment is not defined in terms of physical form. An organism comes to know its environment only in terms of the various kinds of energy which impinge upon its senses. In other words, an architect's building simply does not exist, except insofar as it is able to alter the energy that is conducted, convected, or radiated to its inhabitants.

For the architect, this presents an incredible dilemma: his medium for solving design problems is physical form, yet his client evaluates this design in terms of energy. However, on closer inspection, this dilemma reveals truly challenging opportunities, for in order to create a comfortable habitable environment, an architect must learn to use physical form to control each specific kind of energy that humans can sense. This paper will attempt to set down some principles which begin to guide the architect in his attempts to control environmental energy by means of physical form.

The environment is defined by palpable energy. Both Aristotle and I came to know our respective environments only in terms of what we could see, hear, taste, smell, touch, or otherwise feel. This is equally true whether I am sitting in my office, running in a field, or swimming in the sea. Whatever surrounds me is completely unknown unless it reflects, transmits, or emits some type of energy. On this planet at least, the possible types of energy include mechanical, gravitational, chemical, and electromagnetic. The latter is certainly the most amazing for it encompasses an incredible range of wave lengths which vary continuously from 0.001 Angstroms (10^{-13} meters) to 1 million kilometers. This spectrum contains cosmic rays, x-rays, ultra violet, visible light, radiant heat, radar, television, and radio carrier waves, and electricity. Indeed it is fortunate that humans are capable of sensing energy in only two very tiny bands of this broad spectrum.

Each source in the natural environment may emit many types of energy simultaneously. For instance, incident solar radiation -- sunlight -- not only contains visible light, but also heat, ultra violet, and many other types of energy as well. For the purposes of this paper, we assume that all environmental energy originated at the sun, but that it is described most comprehensively in terms of local climatic data. Every architectural object is designed for a particular location on the earth which determines its climatic context as well as the possible alternative internal energy sources.

Each specific human sense responds to only one particular type of energy in the environment. As a species we have evolved an ensemble of highly specialized techniques for gathering information about our environment. We possess perhaps as many as two dozen highly specialized and quite distinct types of sensory receptors. For instance, we are able to detect minute amounts of electromagnetic energy in that very narrow spectral band we call visible light, by means of two different receptors in the retina, the rods and cones. The latter are also capable of detecting extremely subtle differences in the wave length of this energy -- a discrimination we know of as color. Sound is sensed by a receptor organ in the inner ear known as the organ of Corti. Both taste and smell are dependent upon a complex set of chemical receptors known as olfactory rods and gustatory papillae (taste buds). Our sense of posture and orientation in space is dependent upon reference to the gravity vector which is sensed by at least two types of receptors in the inner ear, the vesticular organs (the utricle and saccule) which detect linear accelerations, and the semi-circular canals which detect rotational acceleration. Other receptors are scattered throughout the body which indicate the differential orientation of the visera and the joints. In addition, there are at least four types of kinaesthetic receptors which are stimulated by the extension of tendons and muscles. Humans also possess at least half a dozen specialized nerve endings immediately beneath the skin which give tactile information about heat, cold, pressure, and pain. Various combinations of these four seem to account for all the other tactile sensations including rough and smooth, hard and soft, wet and dry, tickle and itch. The capallaries near the surface of the skin are also believed to play an important part in detecting thermal information. Thus every human has in his service a sophisticated arsenal of "listening devices," each constantly on the alert for its own particular sufficient energy.

Human sensory processes each respond independently. The autonomy of each human sensory process holds for every type of energy in the environment. For instance, one can hear conversation equally well in a room that is either warm or cool, and conversely one's thermal sensations are independent of whether the room is quiet or noisy. This degree of independence gives the architect a tremendous advantage in the creation of spacial surrounds which are exactly attuned to satisfy a set of environmental needs. This means that if the architect can design a solution to precisely control a particular type of energy, he may be reasonably certain that it will have no affect on the human's sensory response to any other type of environmental energy. In other words, a design solution which controls heat but not sound will not affect the human's sensation of sound.

The objective of environmental control is to maintain all palpable energy within the human comfort range. Unfortunately, it is extremely difficult to precisely specify the maximum and minimum limits of the comfort range for each type of environmental energy. Further out in this same continuum there are another set of limits which specify the points beyond which life is not possible; extreme amounts of any energy can be fatal. Within this viability range, there is a slightly narrower band defined by the maximum and minimum limits within which life is self sustaining. But humans have learned that discomfort is often a precursor of danger, and so will instinctively seek out a still narrower band of environmental energy defined by the maximum and minimum limits within which life is comfortable. The architect's task, of course, is to create environments which encompass the narrowest of these, the human comfort range. In the natural environment everyone has experienced energy states which fall outside the limits of the comfort range. In such a situation, one almost instinctively devises ad-hoc countermeasures which change metabolic rate, clothing, or location, etc. On the other hand, if absolutely necessary the healthy human is able to tolerate extreme discomfort for a considerable length of time. The architect's task would be considerably simplified if he could precisely define the human comfort range, but it turns out that this is impossible.

Shifts in the human comfort range are caused by group differences, individual differences, adaptation, and conscious deviation. The first of these factors which cause the comfort range to shift is socio-cultural or group differences. For instance, most Britishers prefer interior temperatures which range between 65° and 72°F, while Americans prefer a range from 68° to 75°F. Eskimos, on the other hand, find both of these ranges quite uncomfortable. A second factor which produces a shift in the comfort range is individual differences such as age, health, metabolism, etc. It is well known that older people and the very young choose warmer environments than do the rest of the population while active people prefer more air movement and less thermal radiation. The third factor is sensory adaptation which is also known as physiological fatigue and recovery. When the senses have been continuously bombarded with one type of environmental energy, sensitivity to the opposite type is considerably increased. An example of sensory adaptation is the painful glare we experience when walking into the sunlight from an extremely dark room, or the temporary deafness we experience when walking out of a noisy room, or the thermal shock we experience when walking out into the cold winter afternoon. The length of this recovery period is approximately proportional to the duration and intensity of the sensory overload. The fourth and last factor accounting for the differences in the human comfort range is choice or conscious deviation. Some people simply prefer to have the window open or the hi-fi set louder or the lights a little brighter. As a result of each of these four disturbing factors -- and probably others -- it should be obvious that there is no single best comfort range. In fact, a building designed to satisfy a single comfort criteria is as absurd as a suit of clothes designed to fit the average man. Unfortunately, the fallacious concept of the average man still manages to survive within the architectural profession and the elusiveness of the comfort range is still sometimes used for grounds for disregarding human comfort as design criteria.

Shifts in the human comfort range can be accommodated by adaptive control systems or by nonhomogenous environments. The architect must provide a means of environmental control which is responsive to each occupant's particular needs and desires. This may mean that the physical forms themselves have the ability to adapt automatically or to be modified, or it may mean that an energy transducer must actively modify internal energy states. An

Environmental Energy			Human Response				Attributes of Architectural Materials Which Have the Properties of		
Technical Name	Human Comfort Range	Common Name	Sensed As	Sensed By	At Low End of Tolerance Range	At High End of Tolerance Range	Absorption	Conduction	Reflection
Electro-magnetic	(3.5-8.0) x 10^{14} Hz 0.01-10,000 lumens	Light	Brightness (intensity) Color (frequency)	Eyes: .rods & cones retina .cones in retina	No Vision	Glare (blindness)	Black, rough	Transparent* (to visible light)	White, shiny
Electro-magnetic	10^{12}-10^{14} Hz	Infrared radiation	Heat loss or heat gain	Skin: subcutaneous nerve endings and capallaries	Chill	Pain (sunburn)	Black, dull	Transparent* (to infrared radiation)	Shiny
Mechanical	20-20,000 Hz 0-80 db.	Sound	Pitch (frequency) Loudness (amplitude)	Ear: Organ of Corti	No Audition	Pain (deafness)	Mushy, fuzzy	Rigid	Hard & large
Mechanical	65°-80°F	Tempera-ture	Hot or cold	Skin: subcutaneous nerve endings and capallaries	Shivering (frost-bite)	Pain (skin burn)	Mass (high specific heat)	Conductive (metallic)	(see radiation)
Mechanical	About 0 ft. lbs	Force	Touch, feel	Skin: subcutaneous nerve endings	No Sensation	Pain	Soft, resiliant	Rigid, strong	N.A.
Inter-molecular Forces	About 1.0 G	Gravity	Orienta-tion (up-down) Force or weight	Middle ear: .Vestibular organ & semi-circular canals .Propriceptors & kinesceptors	Disorien-tation	Unconscious-ness	Soft, resiliant	Rigid, strong	N.A.
Chemical	At least .0002 ppm	Odor and taste	Odor or taste	Nose & mouth Olfactory buds & taste buds	No Sensation	Bitterness (pain)	N.A.	N.A.	N.A.

*Note: Attributes are energy dependent; for instance, water is transparent to visible light but opaque to infrared, while rock salt is opaque to visible light but transparent to infrared.

alternative strategy is to design environments which are sufficiently heterogenous to allow the occupant to select or to migrate to other locations which better meet his particular preferences.

The architect has at his disposal a selection of alternative means of controlling environmental energy. Almost everything you see about you is environmental control of some type, protecting you from some sort of environmental disturbance or making up for some lack of environmental necessity. Much of this was explicitly designed by an architect or was added by people who came later to correct for the architect's omission. For instance, the walls, windows, doors, ceilings, rugs, lightbulbs, draperies, chairs, and even your clothing controls various types of environmental energy. In fact, our colleagues in the fashion industry have been known to refer to architecture as "clothing at a distance." Consider how many of these objects in some direct way modify sound, heat, or light, and also consider how many of them are in some way adaptable. This means that the architect will inevitably find sufficient degrees of freedom to solve even the most complicated environmental control problem.

Every physical form affects many types of energy. The various attributes of objects and forms which you see about you are the means by which energy is controlled, either by reflection, refraction, transmission, or absorption. For example, consider all the different kinds of energy a wall must control. It reflects sound and light, retains heat, and prevents the passage of wind and snow. It also controls vision both in terms of privacy and view, it can selectively filter out the components of solar energy by transmition, absorption, or reflection. In addition, it also controls the rate of migration of moisture. All the other objects in your environment are similarily operating to control environmental energy.

Each attribute of the physical form controls only one type of energy. The surface properties of smoothness and color account for the reflection and absorption of light. The attribute of fuzziness accounts for the absorption of sound. The object's density is roughly proportional to its thermal capacity or specific heat. Its porosity affects odor propagation, and the rigidity of an object accounts for its sound transmission characteristics. This means that a change in one attribute of an object will not necessarily affect any of its other attributes. This gives the architect sufficient scope so that he can use form to control almost any combination of environmental energies to within almost any limits. For example, it is possible to change the color of an object without affecting its sound reflecting properties, and to change its thermal conductivity without necessarily affecting its weight. Because of the incredible variety of materials available to the construction industry, it is usually possible for the architect to specify the particular set of attributes that are required, and to find a material which precisely fits that specification.

Thus, the problems of environmental control are two-fold in nature. Says Horst Rittel, "On one hand it depends upon the 'external' circumstances, and on the other on what the inhabitant of the environmental niche considers desirable." As we have seen, there need not be a clear correspondence between these two. For this same reason a task of design is also two-fold in nature. On one hand, the architect creates environments by manipulating physical objects, and on the other hand, the environment he creates is evaluated by its inhabitants exclusively in terms of energy.

Thus, the environmental designer is confronted with a dilemma. He cannot directly control each type of energy. He can only manipulate physical forms or objects, but each object which he produces will potentially influence more than one type of energy. Fortunately, for every desired condition or state of the environmental energy, there are alternative strategies of attainment.

In this paper we have discussed only the issues associated with the control of environmental energy. Clearly there are many other factors which influence the design of physical form. A complete list of the determinates of form might include such factors as:

- Control of environmental energy (climate)
- The architect's personal aesthetic heuristics (subjective symbolization)
- Function or intended use (the behavioral system)
- The structural system (load distribution and earthquake resistance)
- Constraints of the site
- Construction technology
- Public safety (building codes, zoning regulations, and other legalistic constraints)
- Access to transportation and communications systems

From this it should be obvious that the architect is responsible for controlling only a few of the necessities of life. For instance, he is not responsible for providing food, medical treatment, love, or the intellectual needs of the inhabitants of his spaces. However, every architect establishes a rank ordering of this list of form determinates for each new design problem that he encounters. The intent of this paper was to suggest that the control of environmental energy may soon lend itself to a more sophisticated and theoretical treatment, and this may prove to become a far more significant determinate of form.

Thus, we can redefine one more aspect of the architect's task: it is to write instructions for making physical forms which among other things maintain all sensible environmental energy within the comfort range of the people who inhabit them.

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DESIGN COMMUNICATIONS: METHODS AND MEDIA

DP2

26: DESIGN DOCUMENTS

COMPUTER AUGMENTED DRAFTING SYSTEM

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INTRODUCTION

It has been stated that mankind has learned more in the last 50 years than he has since the dawn of his existence. Scientists tell us that our collective base of knowledge will double every 10 years. We are further told that we must totally rebuild our cities before the year 2000 because of population increases, obsolescence, and architectural folly.

What have we as architects done to anticipate these future demands? Very little I'm afraid. We persist with our meaningless ethics and antiquated building codes; our fee structure is ludicrous; and our methodologies are obsolete. It's no wonder that critics like John Pastier of the Los Angeles Times calls architecture "a dying art that has become merely irrelevant to contemporary society".

If we look to the AIA, they define the roll of the architect as follows:

> "The architect creates man's environment by designing buildings and building complexes, and the spaces and relationships inside, around, and among buildings and building complexes. The architecture of our towns and cities results from his activities. His deliberations determine how people will be placed in relationship one to another, how whole societies work, play, eat, sleep, travel, worship - how people live. His objective is to bring order to this environment to cause it to function properly within a structure that is safe and healthful and to impart to the whole a beauty and distinction that is appropriate to our times!" (1)

It is hard to accept a statement like that with any degree of credibility. We have a lot of ego, a lot of fanfare, but very little product. Examine the facts! Almost 10 per cent of our Gross National Product is in construction industry, yet the architect is involved in less than two-fifths of the dollar volume. Less than 5 percent of our single family housing is designed by architects. We are no longer the master builder. The "architekton" is dead. We are but pawns in the hands of developers, politicians, financiers, and in many cases, even the contractor. The architect has been reduced to the guy that draws funny little lines on paper.

What are the factors behind this bitter reality? Why is the demand curve for architectural services decreasing? The total answer is complex and beyond the scope of this paper. However, the reason I raise the question is to hypothesize that, one of the significant factors behind the architectural decline is the failure of the architect to incorporate recent advances in technology into his practices.

Universally, all architects seem to believe that all problem solving and analysis is within their capabilities.

Fifty years ago this may have been true. But in today's technology, with its multivariable complexity, it is no longer possible. Except for the most elementary buildings, the architectural process must be an integrated effort of many highly skilled technicians. The unfortunate by-products of integrating various disciplines are increased coordination costs, increased tendency for human error, and duplication of effort.

It is my belief that computer technology can greatly alleviate these deficiencies. It is possible to assist the architect with coordination, analysis, design, and at some point in the future even fabrication of the structure. The more immediate goal is to utilize the computer in such a way that it will assist, planning and coordination, eliminate double task operations, insure accuracy, and stop tedious and mundane drafting of plans and elevations.

Needless to say, the hours and dollars required to achieve this objective are astronomical Yet it will come. Program by program, bit by bit,the goal will be realized. Economics, the almighty dollar, will be the catalyst. The potential cost savings and efficiencies of scale are far too great to be ignored.

COMPUTER AUGMENTED DRAFTING

Our architectural drawing system was started in 1968. We began with little knowledge of fortran, a lot of enthusiasm, but no knowledge of computer graphics. Our first experiment was to take an existing floor plan and digitize it--by hand! It didn't take us long to realize that this was not the way. The conversion of feet, inches, and fractions to decimal x- and y- coordinates was sheer idiocy.

Next we tried automatic digitizing. It definitely speeded up the process and eliminated many of the errors, but it didn't completely satisfy our needs. Intuitively we felt that the basic concept was wrong. In order to digitize a drawing, it was first necessary to have the drawing! We were duplicating effort; this is exactly what we were trying to eliminate.

Objectives

We found it necessary to define what we really expected from an architectural drafting system. We eventually agreed on four major requirements:

1. The system must be flexible; the user must be able to draw many different types of floor plans and room configurations.

2. The input to describe the architectural geometry must be minimal and easy to use.

3. The architectural drawings must be easily edited and highly variable.

4. The architectural geometry should be an integral part of the project data base. The architectural plan together with the analysis of other disciplines should provide the user with necessary reports and tabulations.

Like all creative processes, the development of the system was largely a product of trial and error. Every program modification triggered new ideas and improvements. Even today we are re-thinking our program linkages in order to make the total system both more efficient and comprehensive.

System Flexability

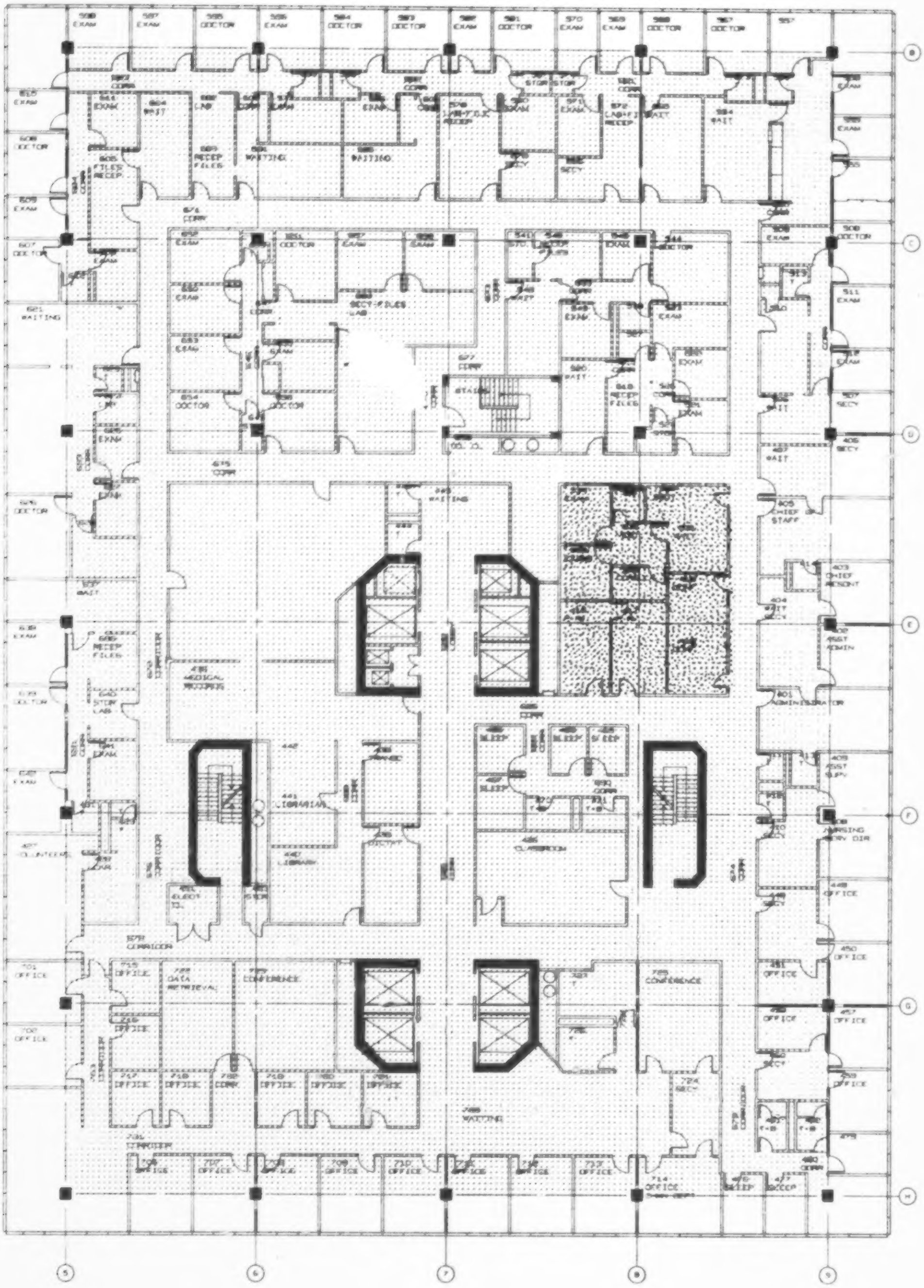
An architectural project is usually a unique entity. Buildings are designed for specific clients in order to satisfy some predetermined objectives. With the exception of high rise office buildings, and warehouses, most architectural plans are a function of room use relationships, traffic flows, and site characteristics. In the aggregate, architectural floor plans tend to consist of various sized rooms that are juxtaposed in diverse ways. Our architectural drawing system is directed at enabling the user to create many different floor plans easily and efficiently.

The program, in its simplest concept, consists of positioning a room or space at a given x- and y- coordinate. The total floor plan is then a product of all of the various rooms at fixed locations. There is nothing revolutionary in thinking of a plan as a finite series or set of rooms. The only reason I am elaborating on the flexible input is to show that it was necessary to define the smallest module which would be common to all types and varieties of architectural plans. It was felt that the manipulation and positioning of walls would be too complex, and we were unable to define a fundamental unit which was larger than a room. Therefore, by elemination, we felt that the largest and easiest building block to use would be the room. If we could have various types and shapes of rooms we could construct and assemble any type of floor plan; this would satisfy our prerequisite for system flexability.

Minimal Input

Having decided that the room was going to be the smallest component in the assemblage of floor plans, it was necessary to provide the user with the ability to easily describe and position different types of rooms. If the process was too complex, the system would never work. Yet if the system was not comprehensive it would have little value in the architectural office. This conflict had to be resolved.

The problem was broken into two components. The first was the room shape and geometry: the second was the position and rotation in the floor plan.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MEDICAL RECORDS
CLASSROOM
CONFERENCE
ADMINISTRATOR
CHIEF STAFF
OFFICE

FIGURE 1. COMPUTER DRAWN FLOOR PLAN
SCALE: 1/8" = 1' - 0"

Room Geometry

For various reasons, man seems to build orthogonal structures. One of the underlying factors may be the T-square and triangle of the architect. But whatever the true reasons, the fact exists that most rooms in most architectural projects are rectilinear. The only information needed to geometrically describe a rectilinear space is the length and width. In order to uniquely identify this space it is usually given a room number and name. This is the basis of our input. In order to describe a room, the user ONLY has to enter the room number-name-length-width.

The L-shaped room, and "rooms" with only two or three walls are variations of this basic input. L-shaped spaces are composed of two, three, or more rectilinear spaces. The system software removes the common wall or walls and handles the rooms as one single space. Two or three sided rooms are handled with simple indicators.

We gave a considerable amount of thought on ways to input curvilinear spaces, but every method we derived required too much input. We finally decided that because of the amount of data required compared to the general frequency of usage, that it would be more economical to manually draw irregular shapes when they occured in the floor plan.

Variation in Walls

A question is usually raised concerning variations in wall thickness. Not every wall in a building is going to be the same. Yet we really didn't want to have to enter each and every wall thickness for each and every room. This would be violating the objective to keep input data at a minimum. We decided on a technique whereby the user established a general wall thickness that would be used on all walls unless it was pre-empted by calling for another variation. This default technique has proven to be quite successful. Our experience has illustrated that less than ten percent of the rooms require explicit input of wall variations. It must be realized however, that this is a function of the architectural design and the construction being used.

Doors, Windows, Openings

In order to insert doors, windows, and other openings into a given wall, the user simply states the symbol he wished to draw and its relative position in the room. The program has a convention in which each wall is uniquely numbered and the user simply states the given wall, the type of symbol, and either an x- or y- displacement from the lower left corner. The computer software makes all the necessary mathematical adjustment. In a manner of speaking, the program erases the wall and inserts a different element or void. If a door or other opening is common to two rooms or spaces, it is only necessary to enter the data once; the user can arbitrarily elect either room.

The doors and openings are related to the individual rooms in order to facilitate room movement, and provide necessary door, hardware, and window schedules. The door or opening is associated with a given wall in a room; if for some reason that room is repositioned, the associated openings are automatically repositioned without user intervention.

Room Positioning

Each room must be given an absolute location on the floor plane in order to properly construct the total plan. This is a simple proceedure of positioning a space at a given x- and y- coordinate. We felt it was undesirable to have to enter the starting x- and y- coordinate for each room; this would be nothing more than simplified system of manual digitizing. We established a convention which assumed that each room would be directly adjacent to the preceding one along the x-axis. Therefore, if a user had a condition where 20 offices were positioned across the southern face of a building, he would simply input the name, length and width of each room. Room 2 would be positioned to the right of room 1, and room 3 to the right of room 2 etc. Obviously, there is a need to perform the same operation in the y- or vertical direction. A command was developed to meet this requirement.

As the system progressed, other commands were developed that enabled us to position any room or component adjacent to a preceding one. The user does not have to concern himself with any co-ordinate values; he simply has to know the length and width of the space he is drawing, and its relative position from the preceding component.

If data entry is logical it often facilitates future changes. For example, if it is necessary to change the width of a corridor and there is a series of 20 rooms positioned on that corridor all the user has to do is change one dimension. The computer will automatically reposition all 20 rooms. Unfortunately, if it was necessary to reduce the size of all 20 rooms because of the increased width, then the user would have to change each and every room.

Room Rotation

Most architectural floor plans are composed of rectilinear spaces that are normal to the x- and y- axis. But there are occasions when a room or a series of rooms must be rotated. Similar to the method of inputing different wall thicknesses. We assume that the angle of rotation from the x- axis is zero unless an exact angle is specified. When a room has a specified angle, it is rotated about its lower left corner.

Data Entry

Throughout the development of our system, we assumed that it would be a simple matter to educate architects on the proper method of filling out coding forms.

The individual architects with whom we made our test study either couldn't or wouldn't fill out the coding forms properly. We experienced a catastrophic communication breakdown. We assumed the data would be accurate, easy to read, and complete. They believed that somehow no matter what they put down, the computer would make it correct. After several tedious weeks and a lot of four-letter words, we abandoned the concept.

Necessity dictated that we develop a new way to interface our programs with present architectural methodologies. We did a lot of soul searching and seem to have arrived at a relatively effective solution. Rather than have the architect fill out forms, we assembled a clerical team that converts an architectural sketch into a finished document. During the design phase, we first develope an accurate grid-column network with the architect and structural engineer. This matrix is used by the designer in order to arrive at his final solution. A free-hand pentel sketch is given to a clerical team; they do all the coding necessary to produce the architectural drawings.

DRAWING VARIATIONS

The architectural process requires various drawings in order to clearly explain not only the design concept and room relationships, but also the many different systems that are incorporated into the structure. Small scale drawings are required to show the total complex, but larger drawings are required for equipment and furniture layouts. Presentation drawings are usually free of notes and dimensions whereas construction documents label and dimension each and every space. Mechanical and electrical systems need room blanks on which to layout ducts and wireing diagrams. Reflected ceiling plans are used to show the positioning of lighting fixtures and other components. Each of these drawings have their own unique characteristics, but basically they are all permutations of the original floor plan. We felt that it was essential to provide as many drawing options as possible. Computer costs necessitate that there be economies of scale. Inputing data is always a costly process. No matter how efficient the system is, the more uses in which the data can be utilized the more economical and efficient the system becomes.

Scale Change

Changing scale is an easy operation. Its simply changing one number on a control card. If the user only wants a portion of the plan at a larger scale, he can mask the output to obtain the exact portion he desires.

Figure 1. shows a total floor plan of a recent hospital. With the exception of the elevator core, everything was drawn by the computer.

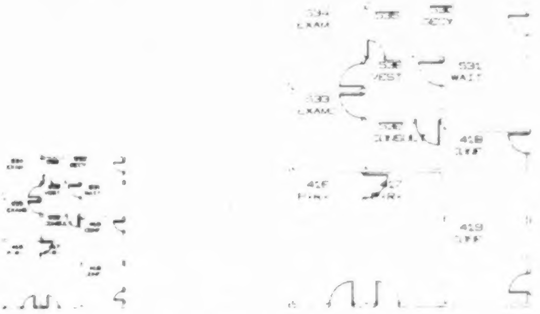


FIGURE 2. SCALE CHANGE

The Figure No 1. floor plan was drawn at 1/8" = 1'-0". In Figure No 2. the user elected to draw only a small portion of the floor plan at a scale of ½" = 1'-0". On the 1/8" = 1'-0" drawing, the small "+" pattern was used to create a matrix on which to position various walls. Instead of dimensioning each space, we felt that the grid pattern would give us a clearer indication of which walls were centered on the module as opposed to "facing" the module. It also inabled us to relate floor & ceiling tile patters within each room.

Room Dimensions

Room dimensioning is another option that the user can easily elect. Instead of using the 1 foot matrix we can dimension each and every space. The dimension can be either on a center line or a face of wall basis. Figure 3 illustrates the dimension capabilities on a center line basis. If the space is too small to clearly identify the room dimensions, the program will omit the arrow and notation. Dimensional accuracy is insured. It's virtually impossible to have a dimensional error on the floor plan. Each room is drawn exactly to scale and any error would be obvious at a glance.

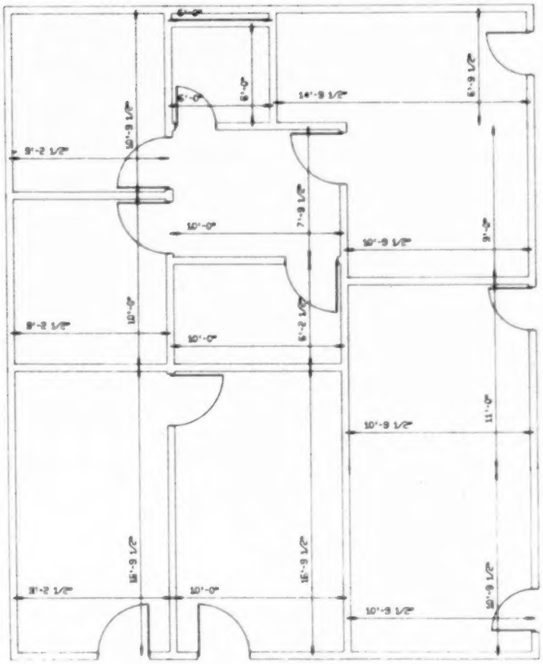


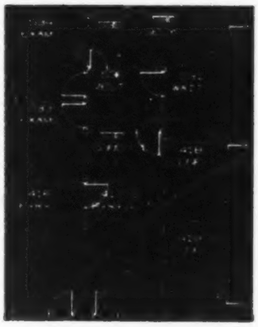
FIGURE 3. ROOM DIMENSIONS

Multiple Uses

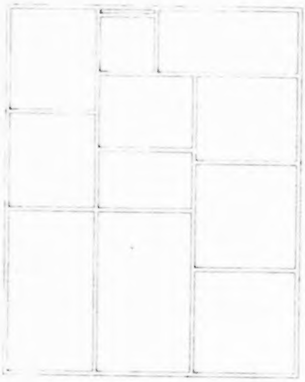
Figures 4, 5, 6 illustrate the other options which the program can provide. The plan can be drawn without room names. It can be drawn with just the room number centered in the space, or it can be drawn as an outline without doors or windows. We are striving to give the user as much flexibility as possible.

Light Fixtures

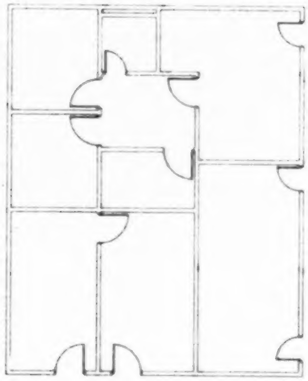
We found that we were able to develop routines that would automatically position lighting fixtures. We eliminated the need for a draftman to spend time centering fixtures. The program automatically determined a symetrical configuration and relates it to the building grid or room module. Figure 7 is a typical example.



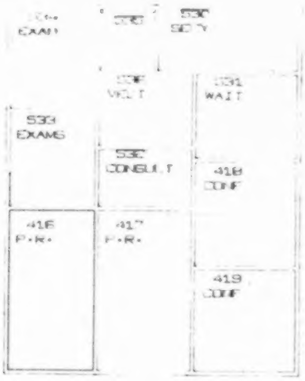
BASE PLAN



ROOM BLANK



ROOM BLANK W/ DOORS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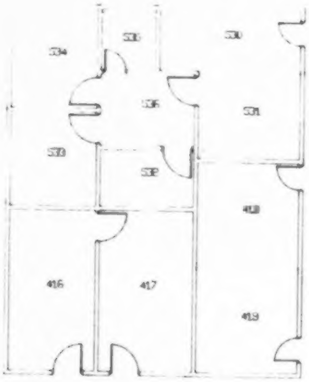
ROOM W/O DOORS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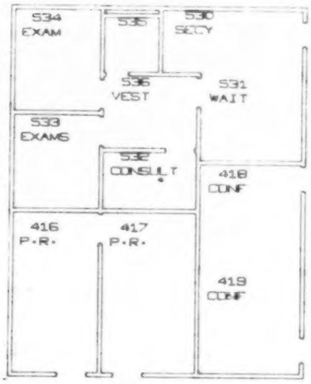
ROOM NUMBER CENTERED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VEST
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WAIT
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EXAMS
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CONSULT
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P.R.
419
CONF

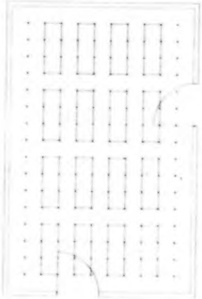
ROOM W/O DOOR SWINGS

DRAWING VARIATIONS

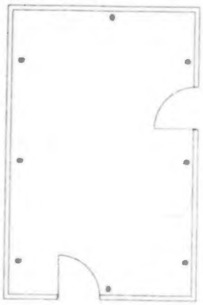
FIGURES 4. - 5. - 6.

Duplex Outlets

In a similar manner, we can automatically position most of the convenience outlets that are necessary to each space. The user only has to input the minimum number per wall and the maximum length of run, the computer will do all the necessary centering. Figure 8 illustrates the standard positioning of duplex outlets.



LIGHTING PLAN



DUPLEX OUTLETS

FIGURES 7. - 8.

Interior Elevations

The types of openings in each wall are known. The computer file has both the plan and elevation configuration stored in the component file. The only missing variable needed to draw interior elevations is the floor to finish ceiling height. Knowing this dimension we can provide the architect a typical elevation. Each wall has both the specified materials and dimensions listed.

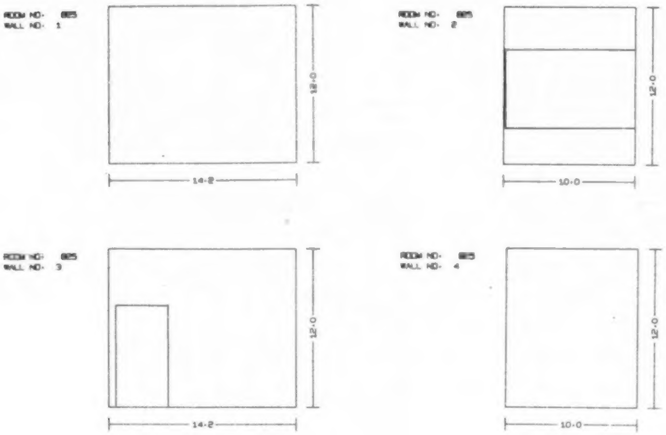


FIGURE 9. INTERIOR ELEVATIONS

COORDINATION

We like to think of the computer as a sort of project coordinator; a machine that will not only do all the accounting functions, but one that can look at many interdisciplinary studies and determine areas of possible conflict.

Concurrent with the architectural design development, the structural engineer must analyze and design the structural system. Many of his investigations are performed with computer assistance. The geometric results of his studies are automatically incorporated into the architectural drawings. In a similar fashion we utilize the architectural geometry to analyze the heating, ventilation, and air conditioning requirements. We are striving to maximize the utilization of the information and minimize the possibility of error.

Room Control

The project data base facilitates the production of a wide variety of reports. The listing below (Figure No. 10) provides the architectural administrator with the location, size and occupancy of each room in the building complex; it compares the design area with the requirements of the client and provides a history of all program changes.

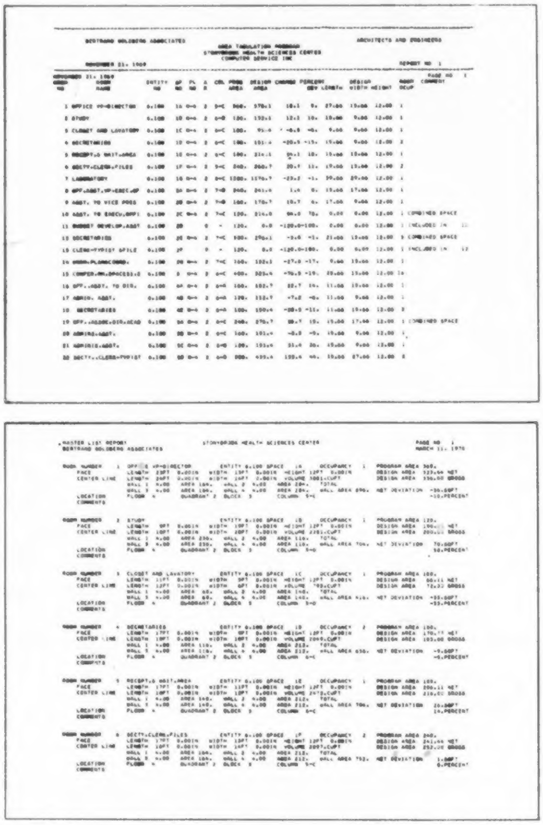


FIGURE 10. ROOM CONTROL AND AREA ANALYSIS

The information may seem trivial, but on complex projects, room reports of this nature are essential for control. The report above was tabulated in room number sequence; it is also available alphabetically, by floor, or two sub-sort codes. The various subtotals were important for funding application, egress analysis, code studies, and determining the adherence to the client's program.

Quantity Surveys

We found it necessary to also have accurate listings of our wall surface, floor and ceiling areas. The report in Figure 11 was used for estimating interior material costs. The data was also used by our Quantity Surveyor in order to provide input to our cost estimating program. At the present time this is still a manual operation, but we are working toward total integration of the quantity and cost reports.

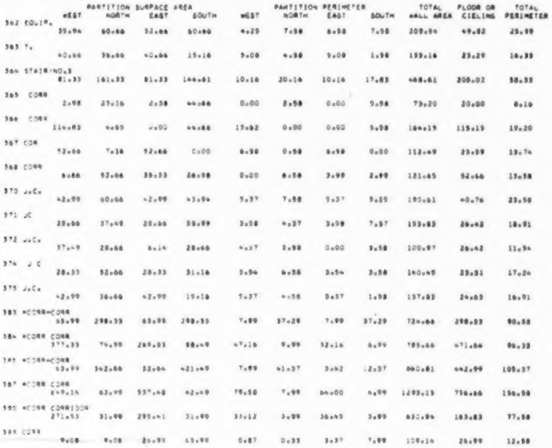
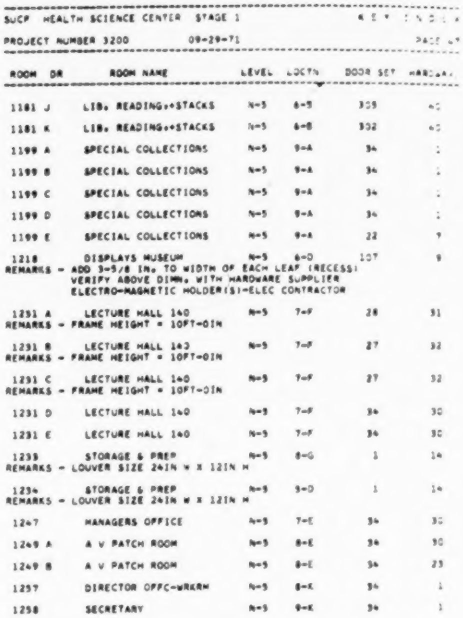


FIGURE 11. SURFACE AREAS

Door Schedules

The door information that was input for the architectural floor plans is utilized in the production of the door and hardware schedules. A four digit number uniquely identifies the type of door, material, finish, width, height, depth, etc. In order to produce comprehensive schedules, this information is supplemented with information describing the frame and hardware components. Two report variations are produced. The first closely relates to the standard architectural listing. (Figure 12) In addition to the type of doors and hardware, it also provides the location of the room and the related architectural details for the head, jamb, and frame.



```
--------------------------------------------------------------------------
SUCF  HEALTH SCIENCE CENTER  STAGE 1                      K E Y   I N D E X
PROJECT NUMBER 3200          09-29-71                              PAGE 49
--------------------------------------------------------------------------
 ROOM  DR        ROOM NAME              LEVEL  LOCTN    DOOR SET  HARDWAR
--------------------------------------------------------------------------

 1181 J     LIB. READING.+STACKS        N-5    6-5        335        42
 1181 K     LIB. READING.+STACKS        N-5    6-8        332        42
 1199 A     SPECIAL COLLECTIONS         N-5    9-A         34         1
 1199 B     SPECIAL COLLECTIONS         N-5    9-A         34         1
 1199 C     SPECIAL COLLECTIONS         N-5    9-A         34         1
 1199 D     SPECIAL COLLECTIONS         N-5    9-A         34         1
 1199 E     SPECIAL COLLECTIONS         N-5    9-A         22         9
 1218       DISPLAYS MUSEUM             N-5    6-D        107         9
REMARKS - ADD 3-5/8 IN. TO WIDTH OF EACH LEAF (RECESS)
          VERIFY ABOVE DIMN. WITH HARDWARE SUPPLIER
          ELECTRO-MAGNETIC HOLDER(S)-ELEC CONTRACTOR

 1231 A     LECTURE HALL 140            N-5    7-F         28        31
REMARKS - FRAME HEIGHT = 10FT-0IN

 1231 B     LECTURE HALL 143            N-5    7-F         27        32
REMARKS - FRAME HEIGHT = 10FT-0IN

 1231 C     LECTURE HALL 140            N-5    7-F         27        32
REMARKS - FRAME HEIGHT = 10FT-0IN

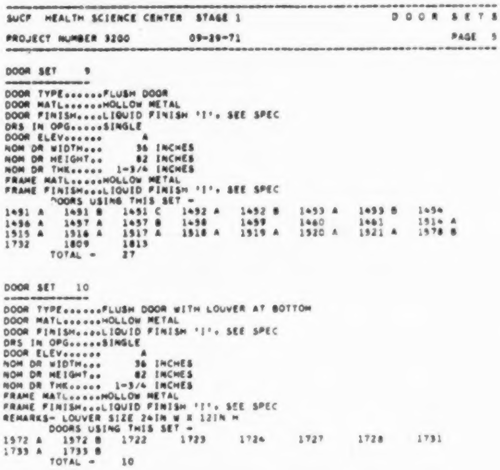
 1231 D     LECTURE HALL 140            N-5    7-F         34        30
 1231 E     LECTURE HALL 140            N-5    7-F         34        30
 1233       STORAGE & PREP              N-5    8-G          1        14
REMARKS - LOUVER SIZE 24IN W X 12IN H

 1234       STORAGE & PREP              N-5    9-D          1        14
REMARKS - LOUVER SIZE 24IN W X 12IN H

 1247       MANAGERS OFFICE             N-5    7-E         34        30
 1249 A     A V PATCH ROOM              N-5    8-E         34        30
 1249 B     A V PATCH ROOM              N-5    8-E         34        23
 1257       DIRECTOR OFFC-WRKRM         N-5    8-K         34         1
 1258       SECRETARY                   N-5    9-K         34         1
```

FIGURE 12. DOOR SCHEDULE

The second report variation provides the user with the location and quantity survey of each component set. (Figure 13) While the architect is not responsible for providing the contractor with exact quantity take offs, hopefully these types of reports will reduce bidding costs enabling the contractor to pass savings along to the client.



```
--------------------------------------------------------------------------
SUCF  HEALTH SCIENCE CENTER  STAGE 1                         D O O R  S E T S
PROJECT NUMBER 3200          09-29-71                              PAGE  5
--------------------------------------------------------------------------

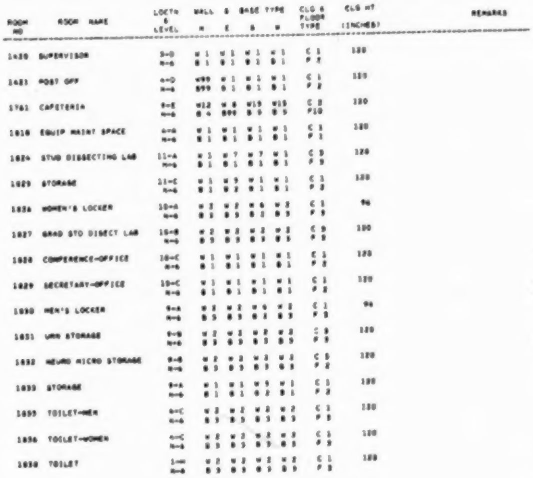
DOOR SET     9
-------------
DOOR TYPE......FLUSH DOOR
DOOR MATL......HOLLOW METAL
DOOR FINISH....LIQUID FINISH 'I'. SEE SPEC
DRS IN OPG.....SINGLE
DOOR ELEV......        A
NOM DR WIDTH...      36 INCHES
NOM DR HEIGHT..      82 INCHES
NOM DR THK.....  1-3/4 INCHES
FRAME MATL.....HOLLOW METAL
FRAME FINISH...LIQUID FINISH 'I'. SEE SPEC
        DOORS USING THIS SET -
1451 A   1451 B   1451 C   1452 A   1452 B   1453 A   1453 B   1454
1456 A   1457 A   1457 B   1458     1459     1460     1461     1514 A
1515 A   1516 A   1517 A   1518 A   1519 A   1520 A   1521 A   1578 B
1732     1809     1813
        TOTAL -    27

DOOR SET    10
-------------
DOOR TYPE......FLUSH DOOR WITH LOUVER AT BOTTOM
DOOR MATL......HOLLOW METAL
DOOR FINISH....LIQUID FINISH 'I'. SEE SPEC
DRS IN OPG.....SINGLE
DOOR ELEV......        A
NOM DR WIDTH...      36 INCHES
NOM DR HEIGHT..      82 INCHES
NOM DR THK.....  1-3/4 INCHES
FRAME MATL.....HOLLOW METAL
FRAME FINISH...LIQUID FINISH 'I'. SEE SPEC
REMARKS- LOUVER SIZE 24IN W X 12IN H
        DOORS USING THIS SET -
1572 A   1572 B   1722     1723     1724     1727     1728     1731
1733 A   1733 B
        TOTAL -    10
```

FIGURE 13. DOOR QUANTITIES/ LOCATIONS

Finish Schedules

The finish schedule is directly incorporated into the bid documents. The one below (Figure 14) is in room number sequence, and lists the room, location, and individual material codes for walls, floors, and ceilings. The exact quantity take off of each finish material can be determined by accessing the room geometry file. These key totals provide us with essential numbers used in estimating the project cost. We readily know the linear footage of base, the square footage of sheet rock, the total surface area to be painted, and the number of ceiling tiles that must be purchased for the suspended ceiling.



```
ROOM  ROOM NAME            LOCTN  WALL & BASE TYPE      CLG &  CLG HT          REMARKS
NO                           &                          FLOOR
                           LEVEL   N    E    S    W     TYPE   (INCHES)
-------------------------------------------------------------------------------------
1420  SUPERVISOR            9-D   W 1  W 1  W 1  W 1    C 1    120
                            N-6   B 1  B 1  B 1  B 1    F 2

1421  POST OFF              4-D   W99  W 1  W 1  W 1    C 1    120
                            N-6   B99  B 1  B 1  B 1    F 2

1761  CAFETERIA             9-E   W12  W 8  W15  W15    C 2    120
                            N-6   B 4  B99  B 5  B 5    F10

1818  EQUIP MAINT SPACE     4-A   W 1  W 1  W 1  W 1    C 1    120
                            N-6   B 1  B 1  B 1  B 1    F 1

1824  STUD DISSECTING LAB  11-A   W 1  W 7  W 7  W 1    C 3    120
                            N-6   B 1  B 1  B 1  B 1    F 3

1825  STORAGE              11-C   W 1  W 5  W 1  W 1    C 1    120
                            N-6   B 1  B 2  B 1  B 1    F 2

1826  WOMEN'S LOCKER       10-A   W 2  W 2  W 6  W 2    C 1     96
                            N-6   B 3  B 3  B 2  B 3    F 3

1827  GRAD STD DISECT LAB  10-B   W 2  W 2  W 2  W 2    C 3    120
                            N-6   B 3  B 3  B 3  B 3    F 3

1828  CONFERENCE-OFFICE    10-C   W 1  W 1  W 1  W 1    C 1    120
                            N-6   B 1  B 1  B 1  B 1    F 2

1829  SECRETARY-OFFICE     10-C   W 1  W 1  W 1  W 1    C 1    120
                            N-6   B 1  B 1  B 1  B 1    F 2

1830  MEN'S LOCKER          9-A   W 2  W 2  W 6  W 2    C 1     96
                            N-6   B 3  B 3  B 2  B 3    F 3

1831  UNN STORAGE           9-B   W 2  W 2  W 2  W 2    C 3    120
                            N-6   B 3  B 3  B 3  B 3    F 3

1832  NEURO MICRO STORAGE   9-B   W 2  W 2  W 2  W 2    C 3    120
                            N-6   B 3  B 3  B 3  B 3    F 2

1833  STORAGE               9-A   W 1  W 1  W 5  W 1    C 1    120
                            N-6   B 1  B 1  B 2  B 1    F 2

1835  TOILET-MEN            4-C   W 2  W 2  W 2  W 2    C 1    120
                            N-6   B 3  B 3  B 3  B 3    F 3

1836  TOILET-WOMEN          4-C   W 2  W 2  W 2  W 2    C 1    120
                            N-6   B 3  B 3  B 3  B 3    F 3

1838  TOILET                1-H   W 2  W 2  W 2  W 2    C 1    120
                            N-6   B 3  B 3  B 3  B 3    F 3
```

FIGURE 14. FINISH SCHEDULE

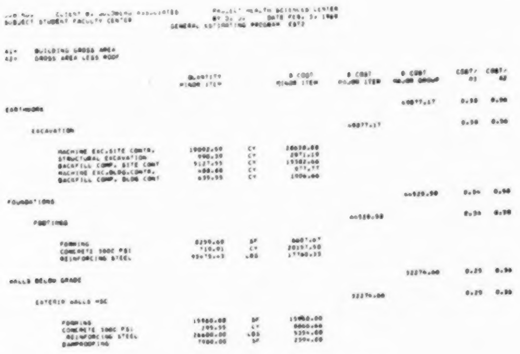
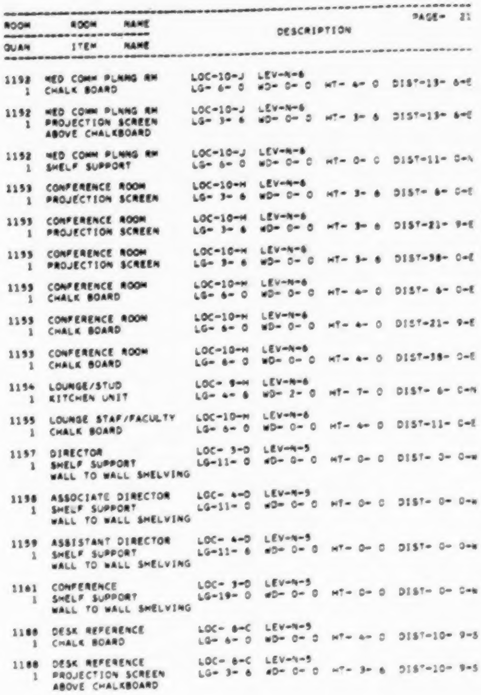


FIGURE 15. COST ESTIMATING



```
--------------------------------------------------------------------------
ROOM      ROOM    NAME                                          PAGE-  21
--------------------------                DESCRIPTION
QUAN      ITEM    NAME
--------------------------------------------------------------------------

1192  MED COMM PLNNG RM     LOC-10-J  LEV-N-6
   1  CHALK BOARD           LG- 6- 0  WD- 0- 0  HT- 4- 0  DIST-13- 6-E

1192  MED COMM PLNNG RM     LOC-10-J  LEV-N-6
   1  PROJECTION SCREEN     LG- 3- 6  WD- 0- 0  HT- 3- 6  DIST-13- 6-E
      ABOVE CHALKBOARD

1192  MED COMM PLNNG RM     LOC-10-J  LEV-N-6
   1  SHELF SUPPORT         LG- 6- 0  WD- 0- 0  HT- 0- 0  DIST-11- 0-N

1193  CONFERENCE ROOM       LOC-10-H  LEV-N-6
   1  PROJECTION SCREEN     LG- 3- 6  WD- 0- 0  HT- 3- 6  DIST- 6- 0-E

1193  CONFERENCE ROOM       LOC-10-H  LEV-N-6
   1  PROJECTION SCREEN     LG- 3- 6  WD- 0- 0  HT- 3- 6  DIST-21- 9-E

1193  CONFERENCE ROOM       LOC-10-H  LEV-N-6
   1  PROJECTION SCREEN     LG- 3- 6  WD- 0- 0  HT- 3- 6  DIST-38- 0-E

1193  CONFERENCE ROOM       LOC-10-H  LEV-N-6
   1  CHALK BOARD           LG- 6- 0  WD- 0- 0  HT- 4- 0  DIST- 6- 0-E

1193  CONFERENCE ROOM       LOC-10-H  LEV-N-6
   1  CHALK BOARD           LG- 6- 0  WD- 0- 0  HT- 4- 0  DIST-21- 9-E

1193  CONFERENCE ROOM       LOC-10-H  LEV-N-6
   1  CHALK BOARD           LG- 6- 0  WD- 0- 0  HT- 4- 0  DIST-38- 0-E

1194  LOUNGE/STUD           LOC- 9-H  LEV-N-6
   1  KITCHEN UNIT          LG- 4- 6  WD- 2- 0  HT- 7- 0  DIST- 6- 0-N

1195  LOUNGE STAF/FACULTY   LOC-10-H  LEV-N-6
   1  CHALK BOARD           LG- 6- 0  WD- 0- 0  HT- 4- 0  DIST-11- 0-E

1197  DIRECTOR              LOC- 3-D  LEV-N-5
   1  SHELF SUPPORT         LG-11- 0  WD- 0- 0  HT- 0- 0  DIST- 0- 0-W
      WALL TO WALL SHELVING

1198  ASSOCIATE DIRECTOR    LOC- 4-D  LEV-N-5
   1  SHELF SUPPORT         LG-11- 0  WD- 0- 0  HT- 0- 0  DIST- 0- 0-W
      WALL TO WALL SHELVING

1199  ASSISTANT DIRECTOR    LOC- 4-D  LEV-N-5
   1  SHELF SUPPORT         LG-11- 6  WD- 0- 0  HT- 0- 0  DIST- 0- 0-W
      WALL TO WALL SHELVING

1161  CONFERENCE            LOC- 3-D  LEV-N-5
   1  SHELF SUPPORT         LG-19- 0  WD- 0- 0  HT- 0- 0  DIST- 0- 0-W
      WALL TO WALL SHELVING

1188  DESK REFERENCE        LOC- 6-C  LEV-N-5
   1  CHALK BOARD           LG- 6- 0  WD- 0- 0  HT- 4- 0  DIST-10- 9-S

1188  DESK REFERENCE        LOC- 6-C  LEV-N-5
   1  PROJECTION SCREEN     LG- 3- 6  WD- 0- 0  HT- 3- 6  DIST-10- 9-S
      ABOVE CHALKBOARD
```

FIGURE 16. ROOM COMPONENTS

CONCLUSION

This article presents the status of some of our architectural programs. The applications have been primarily directed at eliminating the time consuming activities that are still required by the architect. We are not striving to eliminate the need for architects but rather, we are trying to augment and refine his method of practice.

As this article is being written, new programs and systems are being refined and developed. These programs that will further simplify the task of assembling construction documents. The relevance of the architect is going to depend on his ability to cope with the new technologies.

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(1) Architectural Handbook of Professional Practice, AIA, Washington, D. C. P.4, Chapter 1.

AN ANALYSIS OF COMPREHENSIVE PLANNING REPORTS

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In the past decade a revolution has occurred in planning thought and theory. Many forms of action have been proposed based on a new understanding of planning as a process. (1) Yet the primary tool of the practicing city planner is still the comprehensive planning report. Kruekeberg's recent study of metropolitan planning agencies in the U.S.A. revealed that the primary outputs of the vast majority of these agencies were 13 studies related to traditional comprehensive land use planning. (2) As Dyckman has pointed out, "The over-riding symbol to which city planners continue to cling, whatever their intellectual reservations, is the comprehensive plan." (3)

The comprehensive planning report has been an unqualified success in terms of survival of the species. It was first developed in concept and form by Bettman & Olmsted in the early 1900's. By 1916 most comprehensive reports were already organized in the three major parts: pre-planning surveys of physical, economic and demographic data; a general plan with detailed parts; and appended methods of implementation. (4) Many thousands of reports have been produced since then and the format has persisted to the present time with remarkably little change. (5)

And yet, we may ask, what effect have they had on the growth and development of cities? According to most observers, very little indeed! Even one of the main proponents of the comprehensive physical plan had to admit that "nearly 60 years of experience and experimentation with general plans have produced only modest achievements". (6)

Rarely have plans been implemented as a whole. If they have been used at all, it has been in a very piecemeal fashion. In such cases the results have been generally discouraging, especially in the unanticipated consequences of planning actions: vast transportation systems leading to vaster problems of congestion; urban renewal projects leading to social dislocation; low-income housing schemes leading to uninhabitable disaster areas, such as the recently publicized Pruitt-Igoe Housing Development.(7) Even apparently simple actions, such as minor zoning changes, can have numerous side effects throughout the whole system - effects completely unanticipated in the comprehensive plan.

The failure of the planning report to have any beneficial effects in the real world has often been attributed to political and economic factors. At the city level planners are seldom the initiators of development, but only regulate the process once it has started. Even then, they have very little power with regard to business and other interests who make their own plans for development and expansion. Since real estate taxation is the main source of income for municipal governments, whenever planning proposals stand in the way of greater assessment, they are easily amended or disregarded altogether. Political power, what little there is of it, normally supports private interests. (8) At a metropolitan or regional level, there are frequently no effective controls whatsoever. In any event, the actual implementation of most planning proposals would be financially crippling for any urban region.

But while these difficulties surrounding the implementation of a plan are certainly important factors in its ineffectiveness, there may be a more basic reason for its failure in the nature of the planning report itself. Even if a plan were to be implemented in its totality, and planners had all the political and economic power they required, we suspect that the planning report would still be a failure, albeit a more spectacular one. Reports fail, we believe, not because of a lack of political power, but because of an inadequate view of the planning process held by practicing planners, and the consequent methods of decision-making used to produce reports. The results are planning reports which read like a program for large-scale civic sculpture which is somehow supposed to improve people's lives, and dotted with unrelated demographic and economic data included because this can also be plotted on maps.

In this paper we argue that adequate planning decisions can only be made if the public has been allowed to participate, and if these decisions have been made in a systematic rational way. Based on these values our analysis finds current planning reports grossly inadequate. At the same time we may also have discovered a correlation between their inadequacies and their continuing popularity with planners.

Planning as a Rational and Democratic Decision-Making Process.

Planning may be defined as "a process for determining appropriate future action through a sequence of decisions". (9) In a heterogeneous society it has two main requirements: it must be systematic and rational, and it must be democratic. There are many reasons why this is so. (10) Any urban area contains a diversity of interest groups who see the world differently, and consequently hold different value sets and strive after divergent goals. The setting of planning goals requires consideration of the full spectrum of these values. Because the appropriateness of any action will vary from group to group, planning methods must be comprehensible to all citizens so that they can understand the reasons and assess the goals underlying planning proposals.

Citizens must be heard, or else the planner can never satisfy their felt "needs" and wants, the only possible definition of "real" problems and the only possible purpose of planning. With limited communication between planner and citizen, it is difficult to tell whether a stated problem in a planning report is really a problem at all! This is probably why most recommendations or plans are never implemented.

How best to encourage public participation is a complex question, but the requirement is clear - we must establish a democratic planning process. (11)

If planning is to deal effectively with urban problems and not just traditional notions of land use, then another reason for democratic rational planning becomes obvious. Being complex, urban phenomena have been studied by many different disciplines, leading designers and planners to engage in a practice we have called "pilfering". This means that information and concepts which may be relevant to the formulation of plans and proposals are borrowed from other disciplines when useful. But each discipline has its own point of view, underlying assumptions, and specific methodological and theoretical concerns, making the direct transfer of such knowledge impossible. A satisfactory understanding of a complex problem cannot be achieved through pilfering but requires real interdisciplinary communication.

Unfortunately, our present experience has been that interdisciplinary communication is more apparent than real. This can be clearly attributed to the lack of some commonly agreed upon conceptual framework within which planners and researchers could work. If our goal is to accumulate a body of knowledge about urban phenomena and to make plans and projects comparable and cumulative, then we must establish such a framework, or what we have called a discipline of urban design. (12) As Gans says "planning must be and can be rational - rationality being achieved when planners develop plans or programs which can be proved to implement the goals that are being sought". (13)

Many models of a rational decision-making process have been proposed. Certain basic features are common to most. (14) Values are held by individuals and groups; from these, "needs" or wants are identified in relation to some situation. Goals are set as general directions to be pursued in the belief that ultimately these will satisfy the identified needs. Then, more specific objectives can be determined, which are capable of attainment by specific actions, and whose effects can be measured. A list of alternative strategies or possible solutions is compiled by which objectives may be attained. The consequences that follow upon adoption of each strategy or solution are determined as accurately as possible. These sets of consequences are evaluated by means of a set of criteria or standards which have been developed from stated values and weighted for relative importance. A decision is made: the alternative with the most preferable probable consequences is selected. The decision is implemented: action is taken which modifies the situation. An assessment is made, which evaluates the action in terms of attainment of the objective.

It must be noted that this model of a decision-making process is greatly simplified. Rationality is only very imperfectly attainable for any individual working on a problem. The process becomes vastly more complex for a heterogeneous urban community attempting to make public decisions, but the same basic elements are always involved. (15)

The Study

Ideally then, the value sets and goals of all urban groups must be taken into account in the establishment of possible courses of action, and the evaluation of their consequences. At the very least, because pluralism is still a long way off, proponents of one plan or another must clearly and explicitly state the values and goals underlying their proposals, the specific objectives which the proposal is trying to achieve and give reasonable evidence that their proposal will, in fact achieve these objectives.

It is in relation to the general planning requirements discussed in the previous section that we believe the comprehensive planning report to suffer its major flaws. To investigate this contention, our strategy was to develop a set of criteria from these requirements which could be applied to the traditional format of the report. (16) We could then evaluate a selected sample of reports against these criteria to determine the extent to which they met the requirements and hence the degree of their adequacy in terms of democratic and rational planning.

From the large number of reports locally accessible a smaller population was selected as follows: reports had to have been published since 1960, so that they represented current planning experience; they had to be written in English, as our limited competence in other languages would certainly cause great cross-cultural problems; they had to have been prepared for cities with a minimum population of 100,000, ensuring us of at least some diversity of groups and goals within their planning areas.

After discarding all those reports which did not meet these criteria we were left with a still considerable number. These were then grouped into categories based on scale - district, city, metropolitan region - and on location - Canadian, American, other English language. The actual reports studied were selected at random from these groupings. (17) The intention of this sampling technique was to produce results which could apply to planning reports in general.

Each report was read once in detail noting throughout the places where the criteria seemed to apply. The report was then re-read and a written evaluation, with examples, was made by criterion. Several reports were examined independently by two readers and their written evaluations compared to check for idiosyncracy. A high concensus was achieved, leading us to believe that anyone using our method and our criteria would make a similar assessment of the reports.

Although the sample is too small for our findings to have statistical validity, the indications were clear. (18)

Summary of Results

A summary of the evaluations by criterion is presented in Figure 1. We found negligible differences between the groups of reports on geographic or scale basis. For the purposes of our discussion, these differences are ignored and the 18 reports are considered as one population.

The most surprising finding was that in spite of the looseness of our criteria not one report was even minimally adequate as a rational decision-making tool.

Most reports were filled with circular reasoning, preconceived solutions and self-fulfilling prophesy, in which it was apparent that problems and objectives had been determined and data selected after the solution was designed. Many decisions were based on popularizations of social science theory, superficial analogy and doubtful rule of thumb.

The necessity for the participation of citizens in decisions which would affect their lives was almost ignored. Some reports paid lip service to the idea, and two actually tried to encourage it, but mostly the solution was assumed to be a foregone conclusion; citizens were involved only because it was necessary to "sell" the proposal to them in order to get it implemented.

Finally, we found that reports were so muddled that they had to be accepted or rejected as a total package; there was no way to cut through the dense underbrush of irrationality, naivety and tautology. Ideally a report should be structured in such a way as to make analysis possible: one might endorse its objectives but find errors in its evaluations of proposals; or alternately, one might disagree with its objectives, but find that it proposes a good strategy for achieving them. As most reports now exist, they are impossible to assess, and consequently quite useless in a democratic society.

Criteria and Examples

In this section, the criteria are summarized and examples given where appropriate. A report had to satisfy the main criteria of each group to be judged adequate.

GROUP 1. Reports must reflect a rational decision-making process. These criteria aim to make critical evaluations of reports possible by citizens, public officials and other professionals.

1.1. Value premises and goals must be explicitly stated. Not one report satisfied this criterion. Values were always implied by the way planners regarded urban phenomena, by the very problems they chose to deal with, and by the kinds of data and projections they considered important (this aspect is discussed in GROUP 3 criteria). There were literally hundreds of examples of implied value statements in the eighteen reports. For example, planners usually valued visual order and efficiency of organization. "The

Report	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	3.1	3.2	3.3	3.4	3.5	3.6	3.7
								CRITERION								
A	–	–			–	–	–	+	+	+	+	+	–	–	–	–
B	–	–	–	–	+	–	–	–	+	+	+	+	+		+	–
C	–	–	–	–	–	–	–	–	+	–	+	–	–	–	–	–
D	–	–	–		–	–	–	–	+	+		–	–		+	–
E	–	–	–		–	+	–	+	+	–	+	–	–		–	–
F	–	–	–	–	+	–	–	–	+	+	+	+	–	–	+	–
G	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–
H	–	–	–		–	+	–	–	+	–	+		–	–	+	–
I	–	–	–	–	–	+	–	–	+	+	+		–	–	–	–
J	–	–	–	–	+	–	–	–	+	+	+	–	–	–	–	–
K	–	–			+	–	–	–	+	+	+		–	–	–	+
L	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+
M	–	–		–	–	–	–	–	+	+		+	–	–	–	–
N	–	–		–	–	+	–	–	+	–	+	+	–		–	–
O	–	–	–		+	+	–	+	+	+	–	–	–		–	–
P	–	–	–		–	–	–	–	+	+	–	–	–		–	–
Q	–	–	–		+	+	–	+	–	+	+		–		–	–
R	–	–	–		–	–	–	–	+	+	+	+	+		–	+
Total	0	0	0	0	6	6	0	4	17	13	12	6	2	0	4	3

Key: acceptable +; unacceptable –; not applicable left blank.

FIGURE 1. Evaluation of Reports by Criterion

commercial core, with its lack of clear structure, functions and looks like a series of strip commercial streets...not as a cohesive center with the best facilities the city has to offer. As a direct contrast, one has only to view the modern planned shopping center, with its rational visible organization." (N. p.9)

1.2. Objectives must be stated. This must seem like an absurd criterion, because one reasonably assumes that every report would give some idea as to why it was produced. Such, however, was not always the case. The notion of an "objective" implies that it is attainable by some series of actions and that the success of the actions is measurable, at least in principle. Eleven reports presented some sort of objectives, but these were either so vague and general or so precise and specific as to be quite useless. Report N lists five characteristics "basic to the Central District's dominant regional role" - accessibility, intensity, multiplicity of purpose, uniqueness and orientation, and identity. It goes on to state that "the overall objectives of the Central District Plan are to achieve maximum improvement in the effectiveness of each of these characteristics." (N. p.8) But what is the possible meaning of the "maximum improvement in the effectiveness of uniqueness"?

1.3. Criteria used to assess proposals must be given. Of course reports do not present alternatives - invariably they are an attempt to "sell" the proposal presented. But even within this framework the authors must show some reasons why they produced the proposal they did. Not one report presented a clear set of criteria. In several reports, standards were implied but they were of no value in assessing the proposal. Report J identified a number of criteria to be used in establishing "atmosphere or character zones" which would then become the framework for its proposals. These criteria were: number of pedestrians, limit of vision, sound, building heights, land use, rhythm and quality of buildings, traffic flow. Since no values or goals were stated in the report, the relevance of these criteria was not evident. At any rate the report "suggested atmosphere zones within which the city planning department and a group of researchers feel exists a certain definable character which is different from the one next to it." (J. p.13-14) Nine zones - Central Business District zone, monumental zone, backstage zone, etc., were then derived with little or no reference to the criteria. This was not surprising since the criteria are for the most part unusable. How does one establish a zone in terms of sound? And who was this mysterious group of researchers who were able to accomplish such feats?

1.4. Proposals must demonstrably follow from objectives. Since nine reports did not state any objectives at all, this criterion applies only to the other nine. Everyone of them followed a similar format: objectives, principles or conditioning elements, plan or application of principles. This sequence suggested that some kind of development had occurred - i.e. the plan had evolved from the objectives - but in all cases, the progression was more apparent than real. The form was: objective - the city should become an X; proposal - the city is an X. "Downtown... ought to become the executive and cultural centre of...., developed to provide the greatest concentration in the region of urban activities and services." (Q. p.21) The report then presented proposals which presumably satisfied this objective. But one of the proposals is that the Downtown is encouraged "...to become an 'executive city'. In the concept, a single high density core with employment opportunities and public facilities for great numbers of persons...ancillary to a high density core would be districts containing a complete spectrum of activities and uses to enrich and make viable living and working in the metropolitan centre." (p.33) Although this proposal was illustrated with maps, graphs and charts, it was nothing more than a restatement of the objective, which, as we now see, was merely a preconceived proposal.

1.5. A report must show that the proposal will implement the objective. Since urban systems are complex, the consequences of planning actions are not readily apparent. Notwithstanding one report (O. p. 10) which maintained that "the interrelationship and interdependence of the physical, cultural and economic forces with regard to the four major planning problems (housing, open space, employment centres, transportation) is self-evident" (!) it is still no easy matter to evaluate the effects of these "forces" on proposed solutions. Of the reports which passed this criterion, most described the "implications" of their proposals. Report Q assessed the employment, building value of new construction, number of dwelling units and population which would ensue from its proposals, plus some more qualitative assessment of what would occur if its proposals were not implemented: "the image of downtown would gradually decline particularly in terms of environment" (p.69); "the environment would deteriorate over large areas". (p.27) There was no particular reason to believe either assessment. The reports which failed typically lacked any relationship between proposal and goal. Report E described its policy proposals for "the seven systems of the comprehensive plan" (?) but these proposals were never related to its basic goals of improving the environment, enlarging human opportunities and strengthening and diversifying the economy.

1.6. The process of decision-making must be described. Previous criteria in this section required a rational decision-making process. Here the requirements were considerably relaxed, asking only that the planners be aware that decisions can be made in a better than haphazard fashion. A report would be acceptable if it merely described a procedural order. Still, only six reports satisfied this criterion. For example, one report (H. p.I-6) was accepted even though it gave only a graphic illustration of its method of how its plan was developed: it diagramed a sequence involving (1) analysis and projection, then (2) values and goals, then (3) the plan. No further explanation was given.

GROUP 2. Reports must allow and encourage public participation. This is a very abbreviated group since planners are notoriously remiss in this respect. We were of course restricted to dealing only with information contained within the reports and not with outside events. For example, one report (E) maintained that its objectives had been established by public participation. Yet one of its recommendations was to attract middle-class whites back into the city. This action would have resulted in the forced relocation of blacks into areas "where some of the worst of the nation's riots have occurred and living conditions defy imagination". (19) However, we had to accept the report as having passed several of the criteria regarding public participation.

2.1. The public must be actually involved in the production of the report. Not one report was acceptable so that much less stringent criteria for public involvement had to be used.

2.2 A report must encourage and facilitate public response to its plans and proposals. Any report which actually (a) invited public submissions (e.g. Q), (b) outlined an organizational framework which included the public (e.g. E), (c) made recommendations to government regarding public participation, or (d) offered any other method of giving public access to decision-making, was accepted. Reports which paid lip service to public participation without outlining a method for so doing, were not considered acceptable: "There will be an important period for general public discussion". (?) (I. unnumbered) Only four reports were acceptable.

2.3. A report must be written in the appropriate language for its intended readership. The primary concern of this criterion was with cases where technical language was used in reports intended for the public. If a report is overly esoteric, the public will not understand it; decision makers will not receive the necessary feedback. This was a difficult criterion to apply without research into levels of public understanding, consequently in doubtful cases we erred on the generous side. As most reports were rather simplistic, there was little difficulty in so doing. Even so, one report (Q) was unacceptable. This report, which stated that its main purpose was to communicate with the public and actually invited public response, described its proposals in terms of floor space ratios (F.S.R.). Even though F.S.R. was defined, the term was too technical and would be very difficult for the general public to interpret.

GROUP 3. Reports must add to the body of knowledge on urban design. A report should be treated, not as a self-contained event, but as part of an ongoing process. The report should be part of an accumulating body of literature and experience; the quality of proposals should improve in each succeeding report as a result of feedback from professional and public sources, and reports should build on the successes and failures of previous reports.

3.1. Terms of reference must be stated. A majority (13) presented some description of the scope of the report or a literal statement of terms of reference. The usual methods were letters of transmittal from government bodies or outlines of the legal planning responsibilities of the planning agency. (O,P) One report (D) noted "the absence of a brief or directive from the City Council", but that did not deter them from doing a study anyway.

3.2. References must be specified to related reports and surveys. This criterion permits someone to check the report's sources and to investigate unnecessary assumptions and misinterpretations. A majority of reports (12) passed. Reports failed this criterion because they used data or information but omitted references to sources. Report G had a subsection entitled "The Precedents" but neglected to mention where they came from.

3.3. Reports must be internally cross-referenced. This is a simple matter, yet only six were satisfactory. In some, cross references were omitted altogether; in others pages and diagrams were not even numbered or named.

3.4. Abstract and conceptual terms must be defined and used consistently, especially if they have been significant in arriving at proposals. Sixteen reports were unacceptable. Literally scores of examples could be given of the use of vague, imprecise terms which could be interpreted as desired, in cases where definition was critical to the understanding of objectives and proposals. The goal of one report was to achieve "the quality of environment which produces personal satisfaction and a sense of community pride and identity." (E. p.10) It went on to assure us that "...the most important design qualities are those which assure a visually pleasant, secure, satisfying and comfortable environment for daily activities." (E. p.16) All reports used terms such as "environmental quality, bustling activity, dignity (of building and man), unique quality, broad range of opportunities, pleasant environment, ideal community, strong downtown, exciting possibilities." With such an array of undefined terms, confusion is inevitable.

3.5. Sources must be given for theory, methods or findings borrowed from other disciplines. This criterion applied to only nine reports. None were acceptable. Psychology and sociology seemed to be the disciplines most commonly employed but it was impossible to tell for certain.Reports often made direct unsubstantiated statements which, although disguised as objective fact, were in reality the values of one social group: "privacy and the opportunity to choose are basic needs of society" (C. p.31); or "(the pooling of open space around the tallest buildings) creates a large, useful, visual and memorable public square, a sense of place" (K. p.9); or "formerly neighbourhoods often grew naturally into social units" (L unnumbered). In referring to a Chinese community living within its renewal area one report cautioned us about "the delicate structure of a homogeneous social group... (which) is vulnerable to even minor upheavals." (G. p.5) Reports invariably talked about the behaviour of "the pedestrian" and neglected individual, social, economic, political and cultural differences among pedestrians.

3.6. Sources must be given for statements about future trends or principles of urban growth. This criterion was applied only to statements which were fairly crucial in the development of plans and proposals. Four reports were judged adequate. There were many examples of assumptions, trends, states of development and urban principles which were given with no reference at all: "...if the experience of other cities is considered..." (L. p.30); "there is little doubt that the automobile will be with us in twenty years time" (C. p.2.1); "the plan sees principles of physical and functional order as essential; ...they are...means of enhancing the environment and improving the quality of life". (E. p.31).

3.7. The image or model of urban "reality" used must be made explicit. Everyone uses a stock of (mostly) unconscious images and models for understanding his surroundings. Models vary from the descriptive to the predictive, from the informal to the mathematical (20). In experience, models are filters for the observation of reality: they suggest what kinds of observations are important from a potentially unlimited number. Planners, as any group, divide their world of interest into certain types of categories and not others. This criterion requires an explanation of the choice of categories and their sources, and an account of models used. Only three reports were acceptable. One described its principles and prototypes in terms of an "access tree", an activity-circulation model (K. p.9); one described factors which combined to form "ideograms" (R. p.52); one outlined a model based on a theory of organic design (L. p.22). In the remaining fifteen, models were of course used, but at an implicit unconscious level. Report F talked about the "factors of basic significance in the planning process - population, commerce and industry, land requirements, car problems". Why it chose to divide the world up into these particular categories was never stated. Most common proposals were divided into parts, such as transportation, residential, parks and recreation, education, etc. The city or region would then be the sum of these parts, and action taken in each of them, i.e. residential, educational, would result in the achievement of the study's objectives. None of the reports gave any rationale for the use of such categories, implying either that there was none - folk wisdom - or that to the authors the models were so obvious as to make substantiation unnecessary. One report used a model (or metaphor) of the "city as human being" (G. p.6) with character and personality, etc. Other models were also suggested, "city as a school". Then the beautification proposals of the report were supposedly based on the "fundamental principles of contemporary urban life" - choice, access, identity, etc. (G. p.20) Clearly these "principles" imply some sort of model of man and society, but do not relate to city as human being or city as school. The authors were unaware that these models have quite different implications.

Conclusions

The findings of the study led to great confusion in our minds as to the function of comprehensive planning reports. On the one hand they were so hopelessly inadequate that we were continually embarrassed and concerned for the reputation of professional planners and designers. On the other hand, they were, and continue to be, the most popular and persistent product of planning agencies. We hypothesize that the inadequacy and the popularity of planning reports are related phenomena.

In the course of our study, we observed many similarities among the reports: a common format, a common use of tools and techniques, a common set of categories, and a similarity among the attributes of cities considered important. Others have noticed these similarities as well. According to Gans, "despite the diversity of urban life, most of the plans have been so similar that texts could be written about their preparation". (21)

It could be argued that the existence of these texts - and their use in planning schools - is one cause of the similarities in reports. Similarities may also be a result of uniformities in plan-enabling legislation - the legal statutes outlining the functions of planners. (22) But texts and laws are only circumstances surrounding the behaviour of planners which must be based on internalized and learned processes. The internalized processes we have called the image of the city held by planners, using the word "image" in the sense proposed by Boulding: subjective knowledge which largely governs behaviour and which is built up out of past experience. (23)

According to Boulding, private images become public if the various images of the world held by a group of persons are roughly identical. The persons must have similar value systems and be exposed to much the same set of messages. The consequence is the formation of a subculture, or a group of persons sharing a public image. Any special interest group or professional group - such as doctors or planners - can be considered as a subculture.

Given this point of view, we regard educational institutions such as planning schools, and work institutions such as planning offices, as mainly socializing agencies wherein students and beginning practitioners learn to be planners. "He must learn the values of his profession in general and in specific, he must puzzle through many dilemmas before experience results in moral decisiveness...The development of a professional self-conception involves a complicated chain of perceptions, skills, values, and interactions." (24) In other words, he acquires a professional image.

One of the main features in a socializing process is the acquisition of the language spoken by members of the culture or subculture. It is through the use of language - through a sharing of messages - rather than through direct observation, that one learns to see with the eyes of the other professionals and to develop the common public image. The process may be partially described by the Whorf-Sapir hypothesis (25): that the language one speaks predisposes one to perceive reality in a certain way. This hypothesis, for which there is conflicting evidence (26) is usually taken to hold for different linguistic communities, or generally for differences at a cultural level. However, we expect the hypothesis also holds at a subcultural level, for the community of speakers who share the public image of planners.

Apart from words, which were the main subject of our study and which were found to be used very poorly, planners - at least the older, architecturally trained ones and the ones who control and staff planning agencies - speak a language based on maps and plans, photos and sketches, tables and three-dimensional physical models. These media are the filters by which planners perceive the city, the means by which they collect information, perform mental operations, and communicate with their colleagues. (27)

The distinguishing characteristic of all of these media is that they cast a visual bias to understanding, and present a static, simplistic image of the city. They predispose planners to pay attention to a very limited range of urban phenomena, namely those pertaining to "physical form" as visually perceived. (28)

For most planners, then, the city is a visual form, an arrangement of physical features. But concomittant with an image of the city, is an image of how to affect the city - the core activity of the planning profession. Davidoff and Reiner concluded that "procedures and substance cannot be treated separately." (29) If the city is conceived of as a physical form, then planning activity must be the manipulation of its parts - the arrangement of buildings and roads, parking lots and plazas.

Ultimately, the practicing planner's view of the planning process seems to be as simplistic as his image of the city. It is conceivable for there to be a common set of general goals for all urban regions - for example, the greatest good for the greatest number - but it is inconceivable that specific objectives should be common to places of differing social, cultural, political and economic contexts, as we found throughout our study. If planning media could take these factors into account, it would be highly unlikely that reports prepared for places as different as the southern United States and England, would aim at the same objectives.

Simon has referred to plans and photographs as state descriptions, which, he says, describe the world as sensed. He contrasts these with process descriptions - such as recipes and differential equations - which characterize the world as acted upon. (30)

The trouble is that master plans describe an end state for the city rather than give instructions on how to get there. In fact, the city is the consequence of myriad actions taken within many complex systems whose effects are often unpredictable and completely unanticipated.

In order to be at all effective we require more dynamic, process-oriented tools. Such tools are beginning to appear, notably the computer simulator, which is able to model and simulate the behaviour of many simultaneously-interacting processes, but they have not as yet had significant effect on our ways of understanding. If our analysis is valid, we are led to the conclusion that planners must radically alter their image of the city before planning methods will improve. (31)

Notes

1. Prominent views of the planning process, which have appeared in the American Institute of Planners Journal, include: Davidoff, Paul & T.A. Reiner. "A Choice Theory of Planning", Journal of the American Institute of Planners, 28 (May, 1962): 103-115. Meyerson, Martin. "Building the Middle-Range Bridge for Comprehensive Planning", Journal of the American Institute of Planners, 22 (1956): 58-64. Altshuler, Alan A. "The Goals of Comprehensive Planning", Journal of the American Institute of Planners, 31 (August, 1965): 186-195. Davidoff, Paul. "Advocacy & Pluralism in Planning", Journal of the American Institute of Planners, 31 (November, 1965):331-338. Friedmann, John. "Planning as Innovation: The Chilean Case", Journal of the American Institute of Planners, 32 (July, 1966): 194-204. Wheaton, William L.C. "Metro-Allocation Planning", Journal of the American Institute of Planners, 33 (March, 1967): 103-107.

2. Krueckeberg, Donald A. "A Multivariate Analysis of Metropolitan Planning", Journal of the American Institute of Planners, 35 (Sept., 1969): 319-325. He concluded that the 13 most frequently conducted studies read "like an archetype work program for traditional comprehensive land use planning and control. Begin with general studies of population and economy, move through a full spectrum of land use studies and highway planning to the general comprehensive plan and follow it all with zoning and subdivision regulations." (p.321)

3. Dyckman, John W. "The Practical Uses of Planning Theory", Journal of the American Institute of Planners, 35 (September, 1969): 299.

4. Hancock, John L. "Planners in the Changing American City, 1900-1940", Journal of the American Institute of Planners, 33 (September, 1967): 290-304.

5. Gans, Herbert J. "City Planning in America: A Sociological Analysis" in People and Plans (New York: Basic Books, 1968): 57-77. Lynch, Kevin. "Quality in City Design" in Laurence B. Holland (ed.), Who Designs America? (Garden City, N.Y.: Anchor Books, 1966): 120-171. Wood, Edward W., S.N. Brower, and M.W. Latimer. "Planners' People", Journal of the American Institute of Planners, 32 (July, 1966): 228-33. Hancock, op. cit. Haar, Charles M. "The Content of the General Plan: A Glance

at History", Journal of the American Institute of Planners, 21 (1955): 66-70. Bassett, Edward M. The Master Plan. (New York: Russell Sage Foundation, 1938). Kent, Jr., T.J. The Urban General Plan. (San Francisco: Chandler, 1964).

6. Kent, op. cit., p.3.

7. A glowing description of the project was originally given in Architectural Forum, 94 (April, 1951): 128-136. The scheme went on to win two awards: the Gold Medal, St. Louis Chapter, A.I.A., 1953, and Honourable Mention, Architectural League of New York, 1953 Exhibitions. With $32 million still owing on it, it is now to be demolished at a further cost of $3.5 million because it is completely uninhabitable. Design & Environment (Winter, 1970): p.9, in an editorial, comment on this disaster of the first magnitude. On the very next page they describe a scheme for Welfare Island, N.Y., which is to house 20,000 people. The two schemes are shockingly similar. The accounts contain the same lavish use of glowing adjectives, but more important, as far as we can ascertain the thinking behind and discussion of the two schemes appears almost identical! There is no reason to believe that Welfare Island will not be as great a disaster as Pruitt-Igoe!

8. Meyerson, Martin & E.G. Banfield. Politics, Planning, and the Public Interest. (Glencoe: The Free Press, 1955). Altshuler, Alan A. op. cit. Banfield, Edward C. Political Influence. (Glencoe: Free Press, 1961). Martin, C.R. et al., Decisions in Syracuse. (Bloomington, Indiana: University Press, 1961). Banfield, Edward C. & J.Q. Wilson. City Politics. (Joint Center for Urban Studies, Cambridge: Harvard & M.I.T. Presses, 1963). Bolan, Richard S. "Emerging Views of Planning", Journal of the American Institute of Planners, 33 (July, 1967): 233-45.

9. Davidoff & Reiner, op. cit., p.103.

10. These reasons are discussed at greater length in: Gruft, Andrew & Donald Gutstein, "A Method for Resolving Urban Problems", Architectural Research & Teaching, in press.

11. Many theories and models of public participation have been advanced such as advocacy, Davidoff, op. cit., Peattie, Lisa R., "Reflections on Advocacy Planning", Journal of the American Institute of Planners, 34 (March, 1968): 80-88; user studies, Godschalk, David R. & W.E. Mills, "A Collaborative Approach to Planning Through Urban Activities", Journal of the American Institute of Planners, 32 (March, 1966): 86-95; and other strategies, Burke, Edmund M., "Citizen Participation Strategies", Journal of the American Institute of Planners, 34 (Sept., 1968) 287-94; Moynihan, Daniel P., Maximum Feasible Misunderstanding. (New York: Free Press, 1969); Altshuler, op. cit.

12. This framework can be variously thought of as a paradigm: Kuhn, T.S., The Structure of Scientific Revolutions. (Chicago: University of Chicago Press, 1965); Rapaport, Amos, "Observations Regarding Man-Environment Studies", Man-Environment Systems, (January, 1970); or a public image: Pask, Gordon, An Approach to Cybernetics. (New York: Harper & Bros., 1961); Boulding, Kenneth E., The Image. (Ann Arbor: University of Michigan Press, 1956); or what we have called a discipline of design: Gruft & Gutstein, op. cit.

13. Gans, op. cit., p.ix. We do not refer here to the grand but simplistic "objective" rationality of traditional comprehensive planning. This will be shown to be a myth in our analysis of reports and has furthermore been laid to rest in many trenchant critiques; see for example: Young, Robert C., "Goals and Goal Setting", Journal of the American Institute of Planners, 32 (March, 1966): 76-85. Braybrooke, David & C. E. Lindblom, A Strategy of Decision. (New York: Free Press, 1963); Mann, Lawrence D. "Studies in Community Decision Making", Journal of the American Institute of Planners, 30 (February, 1964): 58-65; Godschalk & Mills, op. cit.

14. Davidoff & Reiner, op. cit. Meyerson & Banfield, op. cit. Altshuler, op. cit. Krueckeberg, op. cit. Simon, Herbert A. "On the Concept of Organizational Goal", Administrative Science Quarterly, IX (June, 1964): 1-22. McLoughlin, J. Brian. Urban & Regional Planning. (London: Faber & Faber, 1969).

15. See Bolan, Richard S. "Community Decision Behaviour: The Culture of Planning", Journal of the American Institute of Planners, 35 (Sept., 1969): 301-310; also Simon, Herbert A. Administrative Behaviour (New York: The Free Press, 1965), Chapters, 3,4,5.

16. These criteria were first formulated in a final year student project. See Best, N., W. Clarke, B. Dallin, S. Fass, J. Frith, M. Osburn, J. Redmond, D. Taylor, D. Whetter, "The Architect/Planner Report" (unpublished term project, School of Architecture, University of British Columbia, 1969). We were able to sort them into three groups referring to rational procedures, public participation and development of a systematic body of knowledge.

17. The final categories were: American: district (2); city (2);region (2): Canadian: district (2); city (2); region (2); other English speaking: district (2); city (2); region (2); for a total of 18 reports. The actual

reports used are not cited in specific examples because they were typical. This would divert discussion from planning reports in general to specific plans. The reports used are listed below.

18. We felt that nothing would be gained for rational, democratic planning by making trivial quantitative comparisons and then subjecting them to elaborate mathematical analysis.

19. Stafford, Walter W. & J. Ladner. "Comprehensive Planning & Racism", Journal of the American Institute of Planners, 35 (March, 1969): 68-74. (p. 72).

20. For a discussion of models see: Deutsch, Karl W., The Nerves of Government (New York: Free Press, 1966): Chapter 1-2; Echenique, M., "Models: A Discussion", Architectural Research & Teaching, 1. No. 1 (May, 1970): 25-30; Harris, Britton (ed.), "Urban Development Models: New Tools for Planning", Special issue of the Journal of the American Institute of Planners, 31 (May, 1965).

21. Gans, op. cit., p.61. The texts to which he referred are: Bassett, op. cit.; Kent,op.cit.

22. Haar, op. cit.

23. Boulding, op. cit.

24. Lortie, D.C. "From Laymen to Lawman: Law School, Careers, & Professional Socialization" in H.M. Vollmer & D.L. Mills (eds.), Professionalization. (Englewood Cliffs, N.J.: Prentice-Hall, 1966): p.98. See also E. Greenwood, "Attributes of a Profession", in ibid, p.10-19.

25. For a succinct statement of this school see: French, D., "The Relationship of Anthropology to Studies in Perception and Cognition" in S. Koch (ed.), Psychology: A Study of a Science, Vol. 6 (New York: McGraw-Hill, 1963); 388-428. See also: Whorf, Benjamin Lee, Language, Thought and Reality (Cambridge, Mass: M.I.T. Press, 1956). Perception is used here more in the sense of cognition than of psychophysical perception - the only kind which could be untainted by thought. But there may even be differences at this level, see: Segall, Marshall, D.T. Campbell and M.J. Herskovits, The Influence of Culture on Visual Perception. (Indianapolis: Bobbs Merrill Co., 1966).

26. For a review of the literature see: French, op. cit., Hoijer, Harry, Language in Culture. Memoir No. 79, American Anthropologist, 56. No. 6, Pt. 2. Saporta, S. (ed.) Psycholinguistics. (New York: Holt, Rinehart & Winston, 1961).

27. Bassett, op. cit., one of the principal formulators of the master plan, had three criteria by which something might be included in "community land planning": it must relate to land areas; it must be allocated to community uses; it must be capable of being shown on a map. But see Haar, op. cit., Note 4, for a critique of the map.

28. This may be a consequence of the iconic nature of planning media; that is, "...they denote (only) those objects which have (some of the) characteristics which they themselves have ..." Morris, Charles, W., "Foundations of the Theory of Signs", International Encyclopedia of Unified Science, I. No. 5 (1968): p. 102. An attempt to apply Morris' theory of signs is made in Norberg-Schulz, S.C., Intentions in Architecture, (Cambridge, Mass: M.I.T. Press, 1965).

29. Davidoff & Reiner, op. cit., p. 115.

30. Simon, Herbert A. "The Architecture of Complexity", Proceedings of the American Philosophical Society, 106 (December, 1962): 467-482.

31. The research was aided by U.B.C. Research Committee Grant No. 25-9590; David Whetter & Rick Clark research assistants. We are continuing our study with an analysis of the observed similarities in reports, in terms of commonalities among media used, goals and objectives, phenomena in the district, city or region considered important. We hope to specify more precisely the extent of a common image among planners, and some of its attributes.

Planning Reports

Preliminary Regional Plan for the San Francisco Bay Region, 1966; Chester - A Plan for the Central Area, 1964; Basildon; Master Plan for 140,000 Population, 1965; Restoration Report: A Case for Renewed Life in the Old City (Vancouver), n.d.; The Calgary Plan, 1970; Downtown Vancouver Development Concepts, 1970; Preliminary Outline Plan for the Copenhagen Metropolitan Region, 1961; The Comprehensive Plan of Chicago, 1966; Whitehall - A Plan for the National and Government Centre, 1965; Metropolitan Plan for the Metropolitan Toronto Planning Area, 1966; The Mobile Plan, 1961; Oakland Central District Pl. 1966; Draft Development Plan Metropolitan Winnipeg, 1963; Urban Design Manhattan, 1969; Expansion of Ipswich, 1966; The Plan - Downtown Kitchener, 1965; City of Norwich - Draft Urban Plan, 1967.

AIDS TO IMPROVE THE DESIGNER'S CONTROL OF COST AND PERFORMANCE OF BUILDINGS, AND TO SPEED THE PRE-CONTRACT AND POST-CONTRACT PROCESSES.

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West Sussex County Council,
County Hall, Chichester, Sussex, England.

Problem.

The County Architect's Department of the West Sussex County Council, after examining their position in 1965, decided that in spite of using highly developed industrialised building systems in which they had participated in the design, the time between client brief and occupation was too long. Careful analysis shewed that the processes being applied before a contract was let had become complicated by tradition and it was believed that this could be substantially reduced by rationalisation of the processes and maximum use of the computer.

The second aspect was that the type of buildings we were constructing did not necessarily satisfy fundamental human needs in the most direct fashion and because of this unnecessary sophistications were introduced to combat problems which were not even necessary.

In other words, the problem was seen to resolve itself into two main streams, HOW we were achieving building and WHAT we were achieving.

Method of Approach to Improve Process.

A system of tendering was developed known as serial tendering. This was to overcome several difficulties which were inherent in the conventional tendering procedures. These were:

1. An enforced period of tender for which the main objective was to establish the successful contractor.
2. The tender documents did little to assist the building process.
3. The designer had little knowledge of the possible cost of his designs until after the preparation of complete drawings and receipt of tender.
4. Large sums of money expended by contractors in abortive tendering which was inevitably added to the cost of their successful tenders.

The serial tendering system was based on preparing a schedule of unit items of work covering every item likely to be used in a County Council building programme over, say, a two-year period. The contractors were invited to price these items on the basis that they would be given a guaranteed quantity of work over a two-year period. They were also given an indication of the range of projects which might be given to them and these could include Primary, Secondary Schools, Colleges of Further Education, Fire Stations, Ambulance Stations, Health Centres, etc., and even houses. The items known as preliminaries were also listed for pricing in the documents, in other words, such things as length of contract was taken into account.

Whilst these tender documents were being priced a theoretical bill of quantities was prepared which proportioned the anticipated types of work and this was fed into the computer as a control bill.

When the tenders were received the computer was used to price the control bill against each contractor and the one who achieved the lowest tender was appointed. By the same process different contractors were appointed for different areas of the County, and also for different sizes of contracts, and so a series of contractors prices were held on file in the machine ready to be accessed at any time and for a tender to be produced. However, in order that small items of work did not have to be continually measured and accessed a system of co-ordinated unit quantities known as 'blobs' was set up.

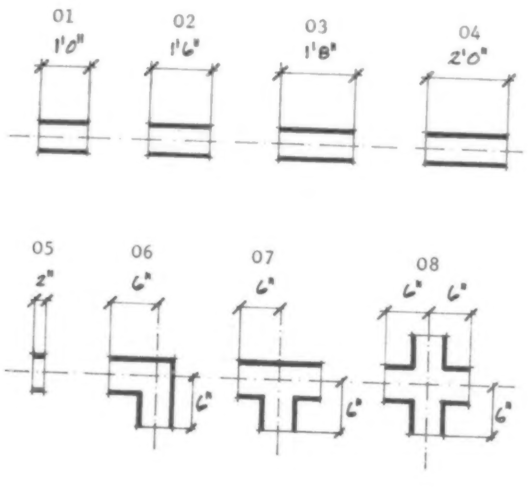
A 'blob' is a dimensionally co-ordinated three-dimensional container of information.

It is possible to reduce the planning requirements of most buildings to a small number of shapes per function with options on height, and this was done.

The building was broken up into functional groups as follows:-

A. Site.
B. Structural support.
C. Vertical envelope
D. Space divider.
E. Base platform.
F. Intermediate platform.
G. Horizontal envelope.
H. Vertical circulation.
I. Environmental control.
J. Servicing.
K. External environment.

Each one of these functional groups was then broken down into blob shapes and each blob shape has as many infills as may be required. The blob shape for space dividers, for example, is as Figure 1.


01
1'0"
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6"
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07
6"
6"
08
6"
6"
6"

Figure 1.

It is these shapes which are used on the IBM 2250 input/output device. Every space divider for example, used in the Department is quantified in terms of these shapes and items within these infills are coded to relate to the original schedule of prices. It will therefore be seen that each time a shape is used and placed into position on the grid and the type of infill indicated, the price is automatically known according to which contractor is being used.

Documents for the system were prepared on a different basis from the traditional form. The information, instead of being of general use to most members of the team, was specifically designed for the user, i.e. the designer, or the contractor, etc., making the document needed by each to be substantially reduced.

By omitting the conventional measurement period and the conventional tendering period the pre-contract process was reduced from sometimes months to a matter of hours. At the same time the office was re-organised on a functional basis instead of the traditional professional basis of architects section, quantity surveyors section, etc. In addition, this change prevented overlapping of processes and made the use of computers a real possibility. Figure 2.

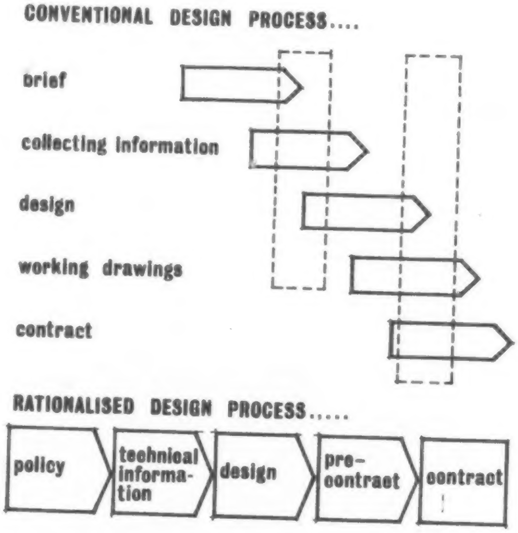
CONVENTIONAL DESIGN PROCESS....
brief
collecting information
design
working drawings
contract
RATIONALISED DESIGN PROCESS.....
policy
technical information
design
pre-contract
contract

Figure 2.

This in turn enabled the status of parts of the organisation to be raised, for example, quantity surveyors who had previously been involved with 'working up' and 'taking off' were now able to be diverted to far more important jobs as cost advisers to the designers.

With the new tool they were able to give exact forecasts of the cost of a building as it was being designed, which had a beneficial effect upon the design of buildings.

The blob system being a container of information is also able to contain information on performance such as heat loss. Therefore the architect is provided with a tool which shews him the effects of his decisions at an early stage. To these programs are being added further programs to enable the steelwork requirements for projects within the system to be evaluated by just indicating a column layout, also the selection of foundations.

At approximately this stage an evaluation of the daylighting and heat loss comparisons will be made so as to enable the architect to choose the balance he requires and subsequently through the whole of the design stage the computer will be accepting his decisions and evaluating right up to the stage where details such as wall finishes are input through the light pen device. Work is also proceeding upon an evaluation of the brief in the form of fundamental activities so that the client's basic requirements can be fed into the machine and sortations leading up to bubble diagrams can be obtained. However, the latter part is still in the research stage.

The IBM 2250 device used in association with an IBM 360/40 now replaced by an IBM 370/155 has been used as a normal office working tool for over two years on the processes described, and has provided many additional services, for example, a Calcomp plotter produces the contractor's layout drawing.

Bills of quantities can be produced for the contractor in any one of the following forms he requests:-

a. In Trades.
b. In Network stages.
c. In sub-network stages.
d. In functional groups.
e. In sections (e.g. Blocks)

Also priced advance information schedules are produced in the following forms:-

a. In trades.
b. In network stages.
c. In sub-network stages.

These are sent to suppliers in advance of a contract being let so that sub-contractors and suppliers can tool up for work which they know to be coming. This speeds up the process.

When this work was got under way attention was directed towards improving the buildings we were constructing and WHAT we were building.

Method of Approach to Improve Environmental Control.

The ultimate objective is to produce buildings which can be erected quickly and give maximum flexibility for the occupants at reasonable cost. However, whilst the traditional processes, particularly in engineering, persist it is unlikely that this aim can be achieved. For example, the fitting of pipes and radiators or similar systems reach a limit whereby they cannot be speeded any further.

In addition, there are many other problems and so a small primary school was built trying to overcome some of the fundamental difficulties. This building was constructed with a very high degree of insulation and a comparatively small area of window but, at the same time, retaining a Government required daylight factor of 2% on the working surface. It was found that it was possible to reduce the heat load to less than a quarter of that normally expected and similarly the heat gain was also reduced. With such a small energy input required the needs for re-circulation of air was considered to be unnecessary; broadly speaking in a temperate climate the air is re-conditioned and re-circulated mainly because the amount of money expended on heating it is too great to throw away. However, in this case the amount of energy required was so small that the air was drawn in and extracted at roof level. The heat of the children's bodies and the artificial lighting became significant factors in the heat balance. The small windows were sealed.

After more than a year of occupation the building has been found to give a very high standard of comfort condition at very low cost.

The school was planned on a completely open basis and a system of partitioning made up from 2ft. square plywood panels was provided with the intention that the teachers and children could create their own space within the total envelope. The small windows have splayed reveals on the inside and this not only reduces contrast, but very considerably increases the apparent size of the windows so that visually there is no feeling inside the building of a restricted window area.

Whilst this building had a fairly traditional construction, it has become clear that it would be possible now to produce a rapid erection building system which provided an envelope where the windows were only required for vision and within the envelope a kit of parts provided for the occupants to put together, probably only with advice from the architect from time to time acting more in social terms, but with an expertise in visual and spatial problems rather than as a conventional architect.

Conclusion.

It is hoped that the computer process which dramatically speeds the pre-contract period, and the environmental approach to speed the construction problems, will make a contribution in reducing the present tendency to erect buildings which are by the time of their completion already obsolescent, and furthermore are capable of being amended to suit the occupants requirements without major reconstruction.

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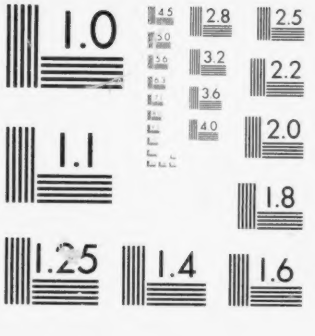
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

12

ANALYSIS OF BUILDING PRODUCTION DRAWINGS

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Introduction

For a generation now there has been overwhelming interest in those aspects of design which are the subject of dramatic and rapidly accelerating change. This interest has been expressed naturally in enthusiastic speculation, experiment, innovation, reports, articles, books, broadcasts, conferences and even, latterly, in research. Think of Urban Planning, Industrialisation, Transportation, Environment Control or Electronic Data Processing.

Meanwhile back at the office designers still draw - much as they always have done. To trained architects in particular drawing is second nature and once learned is a form of communication as unselfconscious as the use of words. Because we are almost unaware of oursevles drawing and because in practice drawing is not changing dramatically and rapidly it has not been given much attention.

Studies in Communications have proliferated, but always the Ugly Sisters, Word and Number, have been pampered excessively while the beautiful Cinderella, Drawing, has been scorned and neglected. No attempts appear to have been made to carry out systematic studies of the nature of drawing as an activity or of the natural history of the drawings in use around us themselves. We recognise that drawings are not independent of other forms of "communication" used in our work but they are so basic and special to the activity of designers that they fully warrant objective study in their own right.

A completed building is, among other things, the product of a design which has been first expressed by means of drawings. Yet only on completion is it safe to say that no more drawings are needed. It should not be necessary to finish the building in order to establish what drawings are needed for its construction.

It was our wish to predict more accurately the nature and number of drawings for projects before completion - in fact, before construction - that led to our first studies in drawings.

Objectives

Our studies had three objectives:-

1. To survey all the drawings prepared and used for a completed project.
   As far as we could ascertain this had never been done before

2. To identify any significant relationships within the survey data.
   Although we expected most of these to be unique to the project we foresaw that numerical data could form a useful basis for comparison with other projects.

3. To establish a method of checking that all necessary production drawings for a project have been prepared.
   In practice some extra drawings seem to be required on every job during construction and not all are due to unforeseen snags. The general intention for most of our projects is to complete virtually all drawings before building starts and we were seeking a procedure for ensuring this.

We first undertook a study of the drawings for a new Secondary (High) School. The results proved so interesting that we followed it up with a matching study of the drawings for a new Maternity Hospital. This was aimed principally at obtaining a second set of data for comparison but also at identifying differences in drawings determined by the building type.

Method

We did not study the drawings of either project until six months after the buildings were in use. For both projects we examined every drawing available. Many design sketches were by then no longer in existence. However we were satisfied that only a very few, if any, drawings issued to the contractor, sub-contractors or suppliers for the purposes of construction (i.e. working or production drawings) escaped examination. If one or two did 'get away' their effects on the data would certainly be marginal.

We scheduled the following data about every drawing:- Office of Origin; Category (i.e. Design or Production (Working) Drawing); Drawing Number; Last Revision; Full Title (clarified if necessary); Size; Scale(s); Stage (RIBA Plan of Work) of Origin and of each Revision; Content Group classification(s); Errors in Basic Data (Information in Title Panel, etc.)

The Two Projects

The first project is an eight-form entry mixed comprehensive school for a local authority. Its development was on an existing suburban school site involving decanting, sectional completions and the retention and up-grading of one existing block. Progress throughout the duration of the project was satisfactory and all target dates were met.

TABLE 1 - PRODUCTION DRAWINGS AND REVISIONS

OFFICE OF ORIGIN	SCHOOL PROJECT Total Drawings	SCHOOL PROJECT Total Revisions	HOSPITAL PROJECT Total Drawings	HOSPITAL PROJECT Total Revisions
1. ARCHITECTS	411	905	365	385
2. CLERK OF WORKS - Site Instructions with drawings	11	-	8	-
3. DRAINAGE CONSULTANTS	54	107	63	27
4. STRUCTURAL CONSULTANTS	526	468	223	51
(Bending Schedules)	(336)	(191)	(161)	(39)
5. M. E. CONSULTANTS	44	69	31	95
6. E. E. CONSULTANTS	34	17	57	244
7. LANDSCAPE CONSULTANT	2	-	-	-
8. LOCAL AUTHORITY (Roads)	-	-	2	-
9. STATUTORY UNDERTAKINGS - Telephones	1	-	-	-
- Electricity	3	-	-	-
10. CONTRACTOR (of these, 36 drawings were copy negatives of S. E. Consultants' drawings used for co-ordination of holes, etc.)	-	-	42	7
11. SPECIALIST SUB-CONTRACTORS, SUPPLIERS, etc. Contract Drawings issued excluding drawings, if any, not issued to design team.	64	36	201	68
TOTAL PRODUCTION DRAWINGS AND REVISIONS	1150	1602	992	877

The total floor area is 103,080 sq. ft. (new buildings) plus 24,605 sq. ft. (up-graded existing building). Estimated final account is £680,000 (new building) plus £52,500 (up-grading existing building). Work on site began in September 1966 and completed March 1969.

The second project is the Maternity Unit of a new District General Hospital for a Regional Hospital Board in the South of England. It is typical of many such units required throughout Great Britain under the 1962 Hospital Building Programme. The Unit contains 96 maternity beds, 6 delivery rooms, 2 operating rooms, a special care baby unit of 20 cots, an Ante-Natal Clinic and a Teaching Department for pupil midwives.

The site, open and landscaped, is in grounds of an existing 19th century mental hospital, just outside a provincial town. There were no sectional completions but handover was complicated by late changes in the brief involving temporary additions and conversions. The contract was completed three months late and progress throughout pre-contract stages was never entirely satisfactory for a variety of reasons. The project forms the first stage of a very much larger hospital development.

The total floor area is 78,250 sq. ft. Estimated final account of £672,300. Work on site began in March 1967 and completed in June 1969.

Both projects are well-defined but by no means standard building types and both were designed and built within the normal cost limits set by central government departments. Both building contracts were let by selective competitive tender on full bills of quantities.

Drawings and Revisions

Because we had not been able to examine all design sketches this study was concentrated on the production drawings. The bulk data is given in TABLE 1 for drawings and for indexed revisions. FIGURE 1 compares the proportional outputs of drawings graphically. (Both projects had structural frames of reinforced concrete and Bending Schedules were made. Because they form such a large group of drawings numerically they are identified in tables and figures to show their effect.).

The most striking aspect of Table 1 is the comparison of totals. While the hospital is 39% smaller than the school in floor area the number of drawings is only 14% fewer and the cost only 9% less. There is another striking difference in the total of revisions and this is discussed below.

In Figure 1, although the architects' share of the total is almost the same for each project, the other differences are of great interest, particularly the contributions from structural engineers, and the specialist sub-contractors.

Drawing Sizes

The apparentlyoverwhelming significance of the A4 size Bending Schedules for the school project is a clear indicator that number of drawings is a relatively crude measure and that amongst other things the size of each drawing may indicate its real or potential importance.

The range of drawing sizes in both projects included every standard traditional size, A1, A2, A3 and A4 standard sizes and an extensive variety of random non-standard size drawings - from 10" x 8" up to 67" x 28". The distributions are shown on FIGURE 2.

FIGURE 3 shows the proportional output of production drawings (figure 1) converted to areas and supports the view that total area is almost certainly a better index than total number of drawings. The bending schedules are reduced to their proper significance and the architects' drawings for both projects are seen to be the biggest single group.

The biggest differences between projects are, first, in the structural drawings which are directly related to floor area and second, in the drawings of specialist sub-contractors, which are directly related to the complexity of the services.

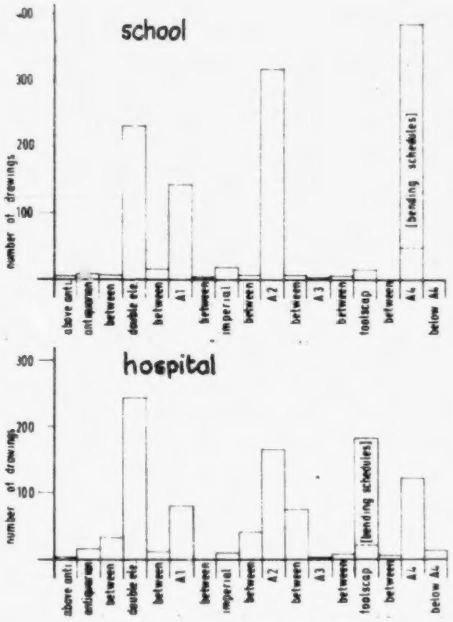

FIGURE 2
Paper sizes used for production drawings

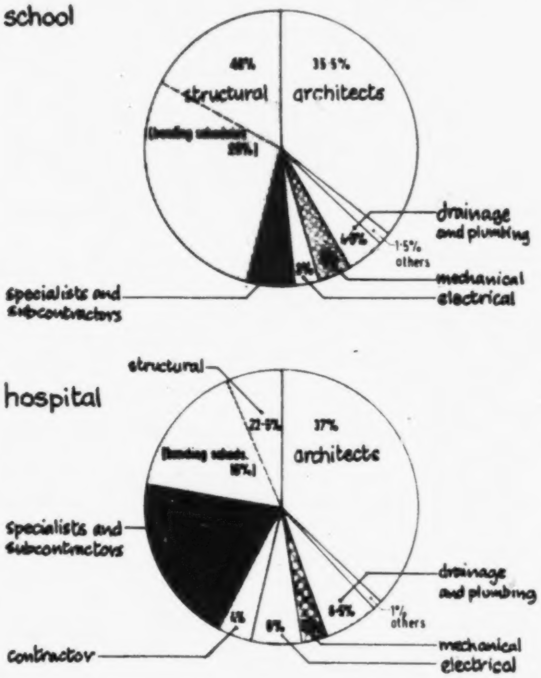

FIGURE 1. Proportional output of production drawings by numbers of drawings

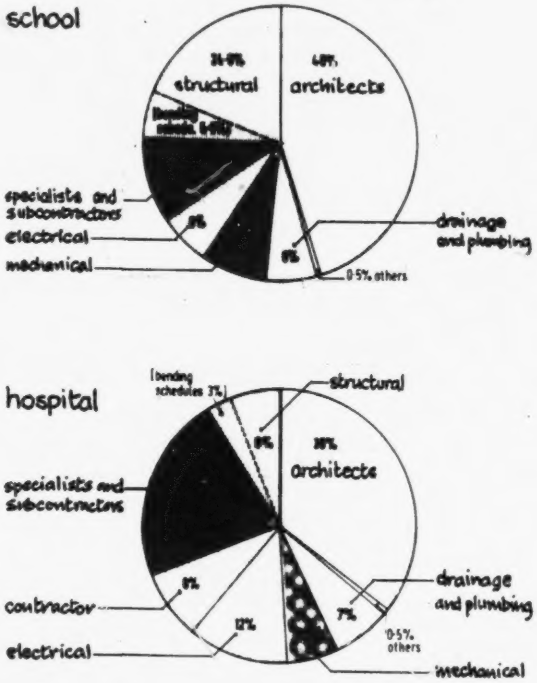

FIGURE 3. Proportional output of production drawings by area of drawings

1110

"Revisions"

Perhaps the most interesting results of all came from the analysis of revisions. Up to now their significance has been largely unrecognised yet our earlier studies indicated that at any given moment perhaps one third of our staff were altering drawings rather than making new ones. For the purpose of these studies we counted each indexed revision on each drawing as a single "revision". The term, of course, covers any difference between two versions of the same drawing. Often it represents the addition of further information or detail, the drawing having been issued for some purposes during the planned process of its completion. A drawing may also be "revised" because what it shows has to be changed or contains a genuine error. Again a 'single' indexed revision can, and for convenience often does, summarise additions, omissions, changes and/or corrections. From Table 1 there are seen to be far fewer revisions overall for the hospital than for the school. Compare however the figures for the Electrical Consultants on each project. For the school they revised their drawings least of all (on average 0.50 revisions per drawing) and indeed stamped all their production drawings "Provisional drawings only". For the hospital the Electrical Consultants revised their drawings most of all (4.28 revisions per drawing) recording each change meticulously.

By chance we seem to have observed two extremes of acceptable drawing practice here. Other important differences in practices were seen - for example Structural Consultants for the hospital made new supplementary detail drawings rather than revise existing ones; for the school the architects deliberately planned the issue of certain drawings at staged completions and these planned revisions accounted for 262 of the total 905. But for the effect of these differences in practice the frequency of drawings with none, one, two revisions etc., would appear to follow a Poisson Distribution as can be seen in FIGURE 4. This distinct pattern suggested that the revisions to drawings might be a reliable guide to many significant features in any set of drawings.

Content Grouping

Each group of these two projects generated around 1,000 production drawings and in each case the architects' share was only just over one third of them. To obtain a general understanding of such a large set of individual drawings we need to see a pattern of larger groups within it. It was thought that by grouping these drawings according to content the set's structure would be further illuminated. For this purpose we used the only "standard" available, British Standard 1192 : 1969, "Recommendations for Building Drawing Practice". This groups drawings by their content in the Production Stage as Location (with 3 sub-classes), Component (with 2 sub-classes) and Assembly drawings. The standard also refers to "Schedules" and to "Standard Details". We attempted to group the drawings for the school project by this method but the allocation was difficult, due no doubt to the fact that the drawings were not made originally with the BS groups in mind, and the results proved of little interest.

But the most significant structure of the sets had already been indicated and is recognised almost unconsciously by all members of the Building team. The first characteristic of any drawing to be 'read' - automatically - is its office of origin. The set of production drawings comprises a number of sub-sets each

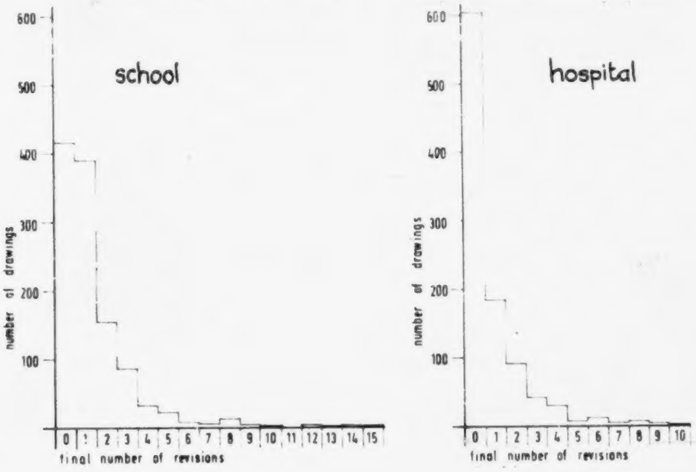

FIGURE 4.
Final revision numbers of production drawings

TABLES 2 & 3 - CONTENT GROUPS OF ARCHITECTS' PRODUCTION DRAWINGS RANKED BY AVERAGE REVISIONS PER DRAWING

Rank	Content Group B.S. 1192 classes shown in brackets - Location (L), Assembly(A), Component(C) and Schedule(S)	No. of dwgs	No. of revs.	Average r/d	Scale LS = Large Scale (greater than ¼" to 1')
SCHOOL					
1.	Floor Layout Plans (L)	25	214	8.60	¼" to 1'
	(excluding three planned revisions to each drawing)	(25)	(139)	(5.60)	
2.	Door Schedules (S)	13	68	5.23	-
3.	Site Plans (L)	2	9	4.50	1/16" to 1'
4.	Furniture Layouts (L)	16	71	4.43	¼" to 1'
5.	Schedules of Architects' drawings (S)	2	8	4.00	-
6.	Roof Plans (L)	5	16	3.20	¼" to 1'
7.	Mounting heights diagram for fixtures (L)	1	3	3.00	½" to 1'
8.	Typical Sections (L)	7	20	2.86	¼" to 1'
	(overall mean for set)			(2.20)	
9.	Key plans and elevations (L)	8	15	1.87	1/16" to 1'
10.	External wall, window and roof details (A&C)	24	41	1.71	LS
11.	Reflected Ceiling plans (L)	16	27	1.68	¼" to 1'
12.	Door frame assemblies (A)	6	10	1.67	LS
13.	General interior detailing (A&C)	59	78	1.36	LS
14.	Staircase Layouts and details (L&A)	5	6	1.20	¼" to 1' & LS
15.	External Works details (L, A&C)	11	13	1.18	LS
16.	Building Programme (-)	1	1	1.00	-
17.	Room Data Sheets (L)	187	298	1.58	¼" to 1'
	(excluding one planned revision to each drawing)	(187)	(111)	(0.58)	
18.	Site Record drawings (L)	2	1	0.50	1/16" to 1'
19.	Schedules of furniture, fittings and equipment (S)	21	6	0.29	-
	TOTALS AND OVERALL MEAN	411	905	2.20	

Rank	Content Group B.S. 1192 classes shown in brackets - Location (L), Assembly(A), Component(C) and Schedule(S)	No. of dwgs.	No. of revs.	Average r/d	Scale LS = Large Scale (greater than ¼" to 1')
HOSPITAL					
1=	Mounting heights diagram for fixtures (L)	1	3	3.00	½" to 1' (LS)
1=	Typical Sections (L)	1	3	3.00	⅛" to 1'
1=	Schedule of furniture, fittings and equipment (S)	1	3	3.00	-
4	Floor layout plans (L)	23	59	2.57	¼" to 1'
5	Site plans (L)	9	18	2.00	1/2500, 1/500 1/16" to 1'
6	Reflected ceiling plans (L)	14	23	1.64	¼" to 1'
7=	Key plans and elevations (L)	24	32	1.33	1/16" to 1'
7=	Door Schedules (S)	3	4	1.33	-
	(overall mean for set)			(1.01)	
9	Door frame assemblies (A)	13	13	1.00	LS
10	External wall, window and roof details (C&S)	48	46	0.96	LS
11	Room data sheets (L)	156	146	0.92	¼" to 1'
12	External works details (L, A & C)	9	7	0.78	LS
13	Schedules of architects' drawings (S)	2	1	0.50	-
14	General interior detailing (A&C)	55	26	0.47	LS
15	Staircase layouts and details	4	1	0.25	¼" to 1' & LS
16=	Site record drawing (Survey) (L)	1	-	0.00	1/1250
16=	Structural co-ordination (L)	1	-	0.00	⅜" to 1'
	TOTALS AND OVERALL MEAN	365	385	1.01	-

defined by an office originating drawings. Table 1 illustrates this but note that the drawings grouped together under item 11 are not a single but sub-set but originate from 14 different firms for the school and 23 for the hospital.

Nevertheless the larger sub-sets - in particular the architects' drawings - are capable of further structuring. The architects' drawings for both projects were grouped following our own standard method and some interesting results were obtained. The school was the first project to be analysed and since we were already aware of the significance of revisions we examined the number of revisions made to drawings in each content group. The average number of revisions per drawing for each group was calculated and when these values were used to rank the groups the results shown in TABLE 2 proved highly interesting. The hospital project, as already noted had far fewer revisions to drawings overall, yet when the same analysis was made it gave strongly confirmatory results, TABLE 3.

The three 'groups' ranked 'first equal' for the hospital are all single drawings and not as significant as they appear. These aside, the overwhelming importance of the floor layout plans in both sets is clear and will be confirmed in the experience of most practitioners

The overall average divides the sets into two. above the mean of both sets there are no large scale drawings and no 'assembly' or 'component' drawings (BS 1192). Site plans of both projects were revised above average, as were also the door schedules - an unpopular and intractable category of drawing. More complex services accounted for the higher rank of ceiling plans in the hospital set.

These tables reflect many other significant features of the projects and the drawing procedures, e.g. revisions generated by changes in the brief for the hospital, and the planned revisions for the school. Clearly therefore it is of value to define content groups and use them for preparing sets of production drawings.

Pattern of Origin and Revision
To throw light on the problem of how to ensure sets of production drawings were completed we counted drawings and revisions originating within each stage of the projects (1). The project programmes are compared in TABLE 4 on the next page.

Stage 4a was defined to assess how well the design team for the school achieved the aim of completing all drawings for inclusion in Bills of quantities.

The results are shown on FIGURE 5 for the school and FIGURE 6 for the hospital as a cumulative frequency diagram to a time scale. The steepness of the graphs indicates intensity of output by drawing offices. For example the architects'

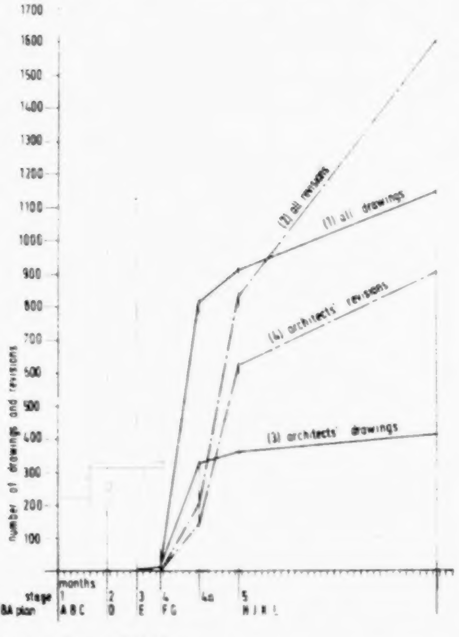

FIGURE 5 - SCHOOL

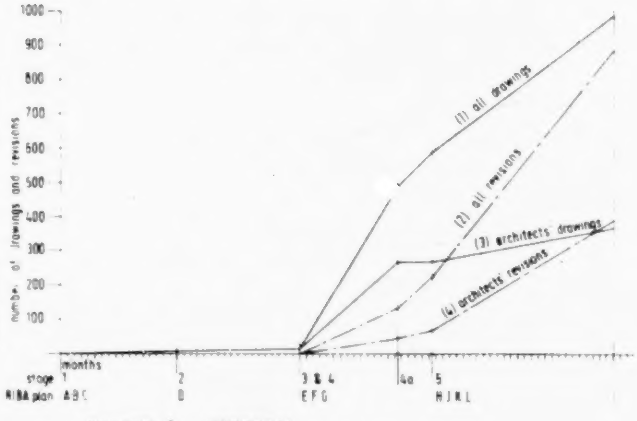

FIGURE 6 - HOSPITAL

Cumulative frequency curves for production drawings and revisions by stages of origin.

TABLE 4 - COMPARISON OF PROJECT PROGRAMMES

Stage (RIBA Plan of Work)	Duration in Months	
	School	Hospital
1. Outline Plan (A, B and C)	7½	17
2. Sketch Design (D)	4½	18
3. Preliminary Working Drawings (E)	3½	14½
4. Final Working Drawings (F and G)	6	
4a. From final issue of drawings to QS for measurement and inclusion in bills to start of work on site (G).	6	5
5. Contract Supervision (H, J, K & L)	30	26½
TOTAL	57½	81

output during Stage 4 for the school project was 318 production drawings and 146 revisions. Office records showed that during this stage there was a full-time team of four. Thus their average combined output was 2.65 new drawings and 1.22 revisions every day for 6 months (120 working days).

The reasons for new drawings being made in Stages 4a and 5 were analysed but it did not prove possible to analyse reasons for the revisions. The slope of the graph for the hospital shows that the rate of revisions to drawings was greater in number for the hospital than for the school. The actual numbers were as follows:-

Stage 5 new drawings - 51 (12½%) School
97 (26½%) Hospital

Stage 5 revisions 283 (31%) School
318 (82½%) Hospital

Discussion

Knowledge gained from these studies illuminates three areas.

1. The projects, as such.

It is widely recognised that hospitals are more complex, more costly per unit floor area, take longer to design and build and in general are more 'difficult' than most other building types. Analysing complete sets of drawings for a school and a hospital have confirmed this with precise data in a number of ways, TABLE 5.

TABLE 5 - COMPARISON OF KEY CRITERIA

	School	Hospital
Briefing and Design period	12 months	35 months
Production Drawings period	15½ months	19½ months
Office originating drawings	23	30
Ratio of Area of drawings/Floor Area of Building	0.031	0.052
Ratio of Building Cost/Floor Area of Building	115/- per sq. ft.	172/- per sq. ft.

Other indicators of the 'difficulty' of the hospital were the greater range and variety of scales and drawing sizes, more errors in basic data and more drawings and revisions made during construction. Always remembering that the hospital was a smaller building.

2. The drawings, as such.

Section 1 of BS 1192 claims to.... "give guidance on the production of building drawings so that information is communicated accurately, clearly, without repetition and with economy of means.". No-one can disagree that building drawings should be so produced. In the course of these two studies well over 2,000 individual drawings were examined. A large number were accurate, clear, without repetition and executed with economy of means.

A number were not, however, and some were so poor they could only be described as sub-professional, for in drawing practice at the moment almost anything goes. Nevertheless, the industry manages to produce buildings from the drawings it prepares. Responsibility for poor drawings rest ultimately with the offices named on the drawings, although draughtsmen can do no better than their best and this depends largely on their training. Section 1 of BS 1192 goes on to state "... The recommendations are also intended as a basis for the instruction of architectural and building students and it is suggested that extensive use of it should be made by educational and training centres." Many draughtsmen, especially in consulting engineers' and manufacturers' drawing offices will have been trained in Engineering drawing using BS 308 (2).

In theory the situation seems no better than in practice. There are a number of widely published statements on the subject of drawings but they do not appear to be based on systematic studies, e.g. the R.I.B.A. Handbook (3) and Research and Development Handbook No. 6 by the Ministry of Public Building and Works (4). Furthermore the latest revision of BS 1192 (5) does not look as though any systematic research supported its preparation and it is safe to say that the standard is not widely known or applied.

The more serious efforts to co-ordinate information (including drawings) such as CBC (6) and CI/SfB (7) remain isolated struggles to impose theoretical solutions on a reluctant industry - there is, so far, little evidence of success. The most striking aspect of the theoretical scene is the total absence of serious published research into the nature and function of drawings. Weakness in theoretical understanding of the subject has led to weakness in teaching drawing and practitioners have to rely on transmitted "know-how" in practice. Thus prior to these studies a search of the technical literature about drawings revealed no other data whatsoever with which to compare results.

It is hard to see how the situation can be improved without concerted action to implement a single soundly-based Standard by all the governing and advisory bodies connected with the building industry.

3. Procedures and methods.

Accuracy, clarity, absence of repetition and economy of means are desirable not only for individual drawings, however, but for the set. It is in this that BS 1192, and indeed every textbook on draughtsmanship to be found in libraries and technical bookshops, is so inadequate. A set of production drawings, such as those studied here is the work of many different people, (perhaps up to a hundred'). How good they are individually may have very little bearing on how good the set of drawings is as a set.

The production of a good set of drawings is not the result of individual skill. It is more a matter of the management and control of a team to achieve a planned objective. At present in the building industry there is no satisfactory understanding of the planned objective - a complete set of production drawings - less still is there adequate management and control to achieve it. The revealed data in these studies and the structure of the sets of drawings were markedly influenced by the very different procedures used in the various drawing offices.

Until more comparative, objective studies are made, however, there are no firm grounds as yet for choosing any particular procedures. What is important is that for each project all the drawing offices concerned should adopt drawing procedures as a team and in advance, each co-ordinating their own preferences and practices with the other. This is already done for some projects but there appears to be a general need for still more precision in defining many key procedures, e.g. co-ordination drawings, checking drawings, the use of copy negatives, and so on, as well as a need, confirmed in these studies, for defining content groups and drawing up checklists for them.

Recommendations

No simple routine procedure, short of actual building, has been devised for a foolproof check that all drawings have been made. This is not surprising considering the varieties of briefing, design, contracting and construction methods in current use. In fact, until the contractors themselves are capable of determining in complete and precise detail what set of drawings is required for production purposes, there will always be uncertainty in this for design teams - sometimes far too much uncertainty. However, arising directly from this study has come recognition of the total set of drawings for the project, its structure of interdependent sub-sets, and the need for the Design Team to plan and co-ordinate the preparation of the set in advance. This is the best approach both to co-ordination and to reducing undertainty and incompleteness in the set.

Accordingly, a code of recommendations for Production Drawings has been drafted and these recommendations are set out as a procedural guide for Design Teams and are based on the need to adapt, extend and refine existing (and therefore viable and familiar) procedures rather than introduce some new and fundamentally different system to which most practitioners respond apathetically or even with hostility:

1. Design Team to plan the set of production drawings by the start of R.I.B.A. Plan of Work Stage E (1).

2. Planned set of production drawings to be scheduled with the following data for each drawing:-

   Office of origin, drawing number, last revision, full title, size, scale(s) and content group. Allocate blocks of numbers where exact number is still unknown.

3. Drawing schedules to be architects' drawings and themselves listed as first group of production drawings in set.

4. Set of production drawings to consist of sub-sets, one for each office making drawings.

5. Drawing numbers and titles to be unique for each drawing. Elaborate codes are only useful if understood, agreed and used

consistently by all.

6. All drawings to be standard A sizes (8), preferably A1. There is a need for a size larger than A1 where the size and shape of the building at the preferred scale demands it. One larger size (A0), Double Elephant, etc.) should be adopted by the Team but only for floor layouts, sections, elevations or site plans which are either too large for A1 or incapable of being sub-divided conveniently.

7. A detailed content checklist for each group of drawings to be prepared and issued.

8. Design Team initially to agree policy and procedures for drawing techniques, basic data, checking, cross-referencing, preferred scales and the use of copy negatives.

9. Review and updating of drawing schedules to be included at agreed stages in the programme.

10. These recommendations to be issued to all specialists, sub-contractors and others preparing drawings for the project.

Conclusion

These studies have demonstrated clearly that our drawings are not as effective as they should be. We cannot improve their effectiveness without wider understanding and deeper knowledge and this can only be obtained by research studies.

As a direct result of these studies our work is already improving in practice. This was our aim but these studies were literally only a beginning and there is still much more to know. At present we are making two further studies of production drawings (9). Another important study of production drawings is being made by the Building Research Station, the major central government agency for building research in Britain (10).

Production drawings are perhaps the easiest kind of drawings to study for their main function is clear. Design drawings in all their wide variety of purpose, however, may be of greater importance. They too must be studied although this will certainly prove very much more difficult to tackle. We feel our studies have indicated something of the nature of all drawing which will therefore help to ease that difficulty.

Acknowledgment

I would like to thank the Partners of George Trew Dunn for permission to publish this paper.

Notes

1. ROYAL INSTITUTE OF BRITISH ARCHITECTS. Plan of Work for Design Team Operation. London, 1967.

2. BRITISH STANDARDS INSTITUTION. BS 308:1964, Engineering Drawing Practice, London 1964.

3. ROYAL INSTITUTE OF BRITISH ARCHITECTS. Handbook of Architectural Practice and Management, Part 3.410, London 1967.

4. MINISTRY OF PUBLIC BUILDING AND WORKS, R & D. Building Management Handbook No. 6 Programming and Progressing in the Design of Buildings, Section 16. London, H.M.S.O. 1969.

5. ALEXANDER, R. BS 1192:1969. Recommendations for building drawing practice: A detailed critique, the Architects Journal, London, 9 July 1969.

6. BINDSLEV, BJORN. CBC - Co-ordinated Building Communication, The Architects' Journal, London, 1st. April 1964.

7. RAY-JONES, A and McCANN, W. CI/SfB Project Manual. The Architectural Press, London 1971.

8. BRITISH STANDARDS INSTITUTION. BS 3429:1961 Sizes of Drawing Sheets. London, 1961.

9. Two studies are currently in progress; the first is the monitoring of all revisions to a set of drawings as they take place during construction; the second is a long term study of the application of the recommendations made here to a large hospital project.

10. The Building Research Station is currently studying the relevance of documents especially the content of drawings and the information search pattern generated. The results of a large sample analysis are due for publication during 1972.

27: SIMULATIONS AND GAMES

ON URBAN INNOVATION THROUGH "U-DIG" GAME

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Abstract

Urban Development Investment Game (U-DIG) was invented by me as a response to the need to develop a gaming tool for the understanding of urban dynamics and for research into urban innovation to improve the quality of urban life.

Three to eight teams of one to four players play in multiple sessions of three to four hours each. A board illustrating a neighborhood plan is used. When an opportunity to purchase occurs to a team, computer developed investment tables are consulted for aid in the decision to buy. Buying, selling, building and bidding all may take place in the course of play. Year end payoffs are made after income tax in a simple bookkeeping procedure. Interest rates and occupancy rates fluctuate. Mortgages are available at the current interest rate. Thus the economic rules are closely patterned after the real world. After an initial period of play, the players become familiar with the dynamics of real estate economics and the basis for decisions that determine the urban form.

In a second version, a news item is distributed that announces the elimination of property lines. Property owners own a proportional share of a block. They can now build dwelling units on top of units owned by others in a common structure that crosses streets within the same density limitations as the first version. Rules are set that establish ground coverage and the relationship on each level above ground. This is one version in which an experiment with a change in one factor in urban form determination is varied to result in a new form, the "quality-of-life" merits of which can be debated. Other rules may easily be changed to study the effects, thus the research possibilities exist.

The value of U-DIG lies in its worth as a tool for understanding existing urban situations (Version One) and as a research device to help develop a better quality of urban life (an example is Version Two). In Version Two, the game sessions indicate some of the problems of planning, phasing and blending a growing mega-structure with an existing urban fabric.

Introduction

This is a study of a study of a process. The environment of the design decision-making process exerts a very strong influence on the form of the city. The more we as designers or we as city dwellers understand this process the better are the possibilities of improving the quality of our urban living. The various "actors" in the process of the development of the environment have been isolated from each other for many reasons such as specialization, the academic division of disciplines, and the complexity involved. The contractor is concerned about completing the building with a good profit margin, the architect is concerned about the building's publishability, the banker is concerned about his building loan, the building commissioner is concerned about compliance to a set of legal regulations and so on, until finally we reach the occupant who is concerned about adapting the building to his specific needs. This process has slowly evolved into its present form. The slow development and the partitioning of the activities of design decision making have resisted and discouraged serious study.

One relatively recent method to study a complex process is through operational gaming. When answers can't be given because the variables are too numerous and inter-dependent, the process may yield understanding through simulation or gaming.

U-DIG Game is a study of the process of the development of city form. It is frankly only an entry and not an exhaustive study. The entry is the attempt to simulate and simplify the financial environment so that it can be a comprehensible component in the game. With this complex but relatively well-definable component designed, the other components can be studied for inclusion in the game. The development of the brute force of computer has made this type of study more possible.

If such a study can lead to the elimination or lowering of barriers, so that the architect understands the influence of the financial structure on the physical structure, so that the banker understands the relationship of his financial decisions to the quality of living in his community, so that the building speculator sees the long lasting effect of short term decisions and the law-maker understands his role in the inhibiting portions of the building code and the zoning laws - then their attention might turn to innovative ways to attain a higher quality of living for all. I proceed from a naive belief that all the "actors" in the environmental design process would genuinely wish to work to improve the quality of life if they were able to break out of their narrow interest constraining cells by understanding their vital roles in attaining a better life.

Simulation Study

The description of the development of the U-DIG Game must start with the antecedent simulation project. In a simulation study, I concentrated on a twenty year span of investments by one investor in a restricted range of opportunities: two, four, six or twenty unit apartment buildings. The simulation was first developed as a manually operated set of forms that required individual computations to arrive at terminal condition summarizing one's net worth at the end of twenty simulated years. After realizing the exhaustive work necessary to run the manual model, I programmed it in Fortran IV. This allowed multiple runs of the model in order to test several strategies of investment. Each of the individual runs would have required many hours of computation with a pencil, paper and electric calculator. Running time on the CDC 6400 computer was only several seconds.

The strategy investigated was: based on the frequency of specific opportunities available (as assumed to simulate real situations) the investor based his decision to purchase on various minimum estimated rates of return from purchase. In general, the rate of return dropped as the investor's strategy was only to purchase properties at a higher or more conservative rate of return.

Objectives of U-DIG Game

The objectives of U-DIG are:

a) Pedagogical - for teaching university students and others about real estate investment and the building process.
b) Research - to investigate better ways of living through manipulation of various factors in the game environment.

The basic design objective in developing the U-DIG Game was:

To be simple, directly comprehensible, to still contain significant parallels to the real world and to provide a base of knowledge for further understanding of the process.

Functional objectives were:

a) To have a visual display of the progress of the community upgrading in the course of the game.
b) To keep the accounting procedures as simple as possible in playing the game, using possibly an adding machine and prepared tables (but not to depend on the availability of a computer).
c) To provide opportunities for using strategies similar to those used in real life.
d) To incorporate consideration by the players for the form of new community buildings and for the site.
e) To be a structure or tool for innovative future research.

The game was designed with a six block neighborhood using a Leggo base with one Leggo block representing two rental units. Red blocks represent all existing construction at the start of the game and white blocks represent all new construction after the start. Zoning has been established to control density and height limitations could be added.

When a blackboard is available, the neighborhood blocks are drawn on it and after each change in property ownership, the title is "recorded" by writing the owner's name on the lot.

Description of U-DIG Game

The typical playing session commences with about thirty to forty minutes of introduction. Player's Manuals are distributed for reference. Three to five teams of one to four players each play in a three to five hour session. Each team designates one person to be bookkeeper. There is no bookkeeping role other than each team's bookkeeper. The introduction is adjusted to the background of the players in general. It consists of briefly outlining definitions and organization of the investment tables. A minimum is explained of the operational rules of the game; these rules are easier understood in the playing. When new situations are encountered, the explanation is given for all players. The playing time for a cycle or simulated year is about forty-five minutes for the first year or two until the players familiarize themselves with the game, then the time per "year" is reduced to about thirty minutes. The game operator should use his discretion on a) whether to have time limits and b) if so, what the limits should be. The game sessions to date indicate that there should be a time limit set on bidding.

To summarize the sequence of play: (see Figure 1)

An amount of U-DIG money ($80,000.00) is issued to each player to start the game. At the start of each year, a die is thrown twice to determine the occupancy rate and then the mortgage interest rate for that year. This simulates the varying actual conditions that do occur.

In the first round, each team in turn rolls the die to determine whether they are presented with an opportunity, an event or a pass.

If an event card is selected, the team reads it and complies with its instructions. As an example, an event might be that all properties on Channing Way are assessed $500.00 each for street improvements. This is then announced to the other teams for compliance.

A pass would indicate that no action is taken. This simulates bad luck in locating reasonable purchases.

An opportunity allows the team to purchase a particular property at its asking price, thus simulating a property proposal being presented to the team for its first consideration. If they decide not to buy at that price, the property is placed for written bid to all teams. In the second round, each team receives an opportunity to purchase.

Then all opportunities not purchased are listed for written bid at one time. Written bids are submitted by each team. Vacant lots have a minimum acceptable selling price of $6,000.00, but the bank or mortgager always evaluates the lot at $10,000.00. For developed property, any bid that is listed in the tables of the Player's Manual may be submitted. Tie bids are resolved by each team rolling a die and the bid is won by the team with the highest number on the die showing. The high bidder buys the property from the bank and receives the opportunity card that then becomes his "deed of title" card. He pays the cash required as listed in the proper page in his set of computer tables. See Figure 2. The proper page is that page with the agreed on purchase price and the mortgage interest rate set for that year and the occupancy rate for that year. He pays full purchase price for vacant lots as no mortgage is available.

Any unbid properties are placed for bid in a second round. All properties still unsold after the second round of bidding are placed at the bottom of the deck of opportunities. The time for bidding should be set from about fifteen minutes for the bidding in the first year to about ten minutes in subsequent years. The timing varies with specific groups and is at the discretion of the game operator.

After the bid period, each team may build on a vacant lot that they own, remodel one of their buildings (the remodeling option seems to slow the game action and has been dropped in recent game runs) or raze one of their existing buildings and construct another. Buildings may be razed by paying off the remaining mortgage. Razing costs are assumed to be zero, simulating that the salvage value is equal to or greater than the cost of removal to the razer.

In constructing a building on a vacant lot, first the builder determines which of two quality construction types and the number of units he wants. The game operator then rolls the die to determine his construction costs; this simulates securing construction bids. As the bank appraises the vacant lot to be worth $10,000.00, the player applies this value to reduce the cash required on the new building mortgage. He then is issued white units (Lego blocks), one block per two units, with which he can then design his new building.

Next, the pay-off time or the end of the year arrives. Pay-off consists of selecting for each property owned the proper "Cash Flow after Tax" figure in the tables. See Figure 2. This accounts

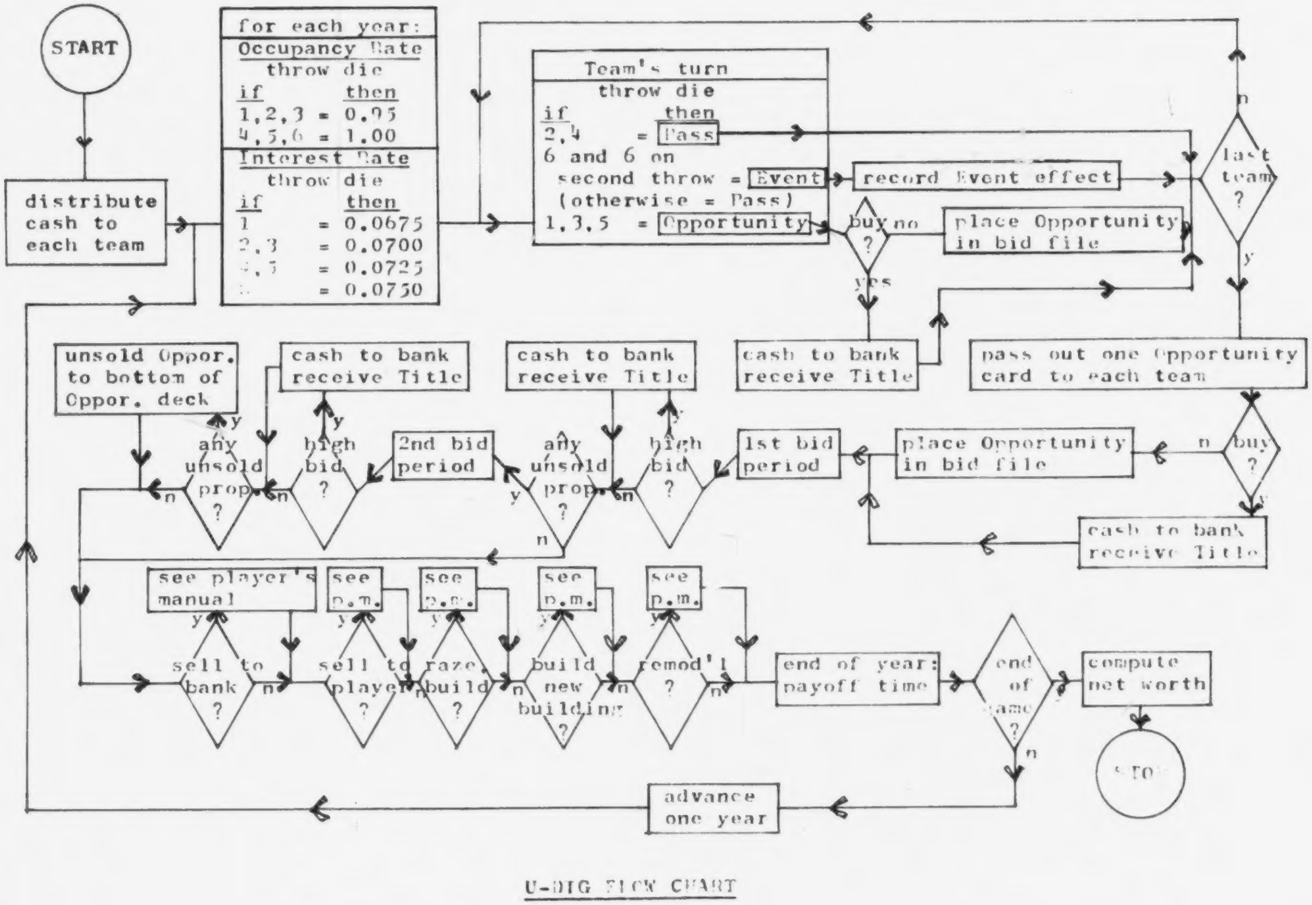
START
distribute cash to each team
for each year:
Occupancy Rate
throw die
if then
1,2,3 = 0.95
4,5,6 = 1.00
Interest Rate
throw die
if then
1 = 0.0675
2,3 = 0.0700
4,5 = 0.0725
6 = 0.0750
Team's turn
throw die
if then
2,4 = Pass
6 and 6 on second throw = Event
(otherwise = Pass)
1,3,5 = Opportunity
record Event effect
buy ?
no
yes
place Opportunity in bid file
cash to bank receive Title
last team ?
n
y
pass out one Opportunity card to each team
buy ?
n
y
place Opportunity in bid file
cash to bank receive Title
1st bid period
high bid ?
y
n
cash to bank receive Title
any unsold prop. ?
y
n
2nd bid period
high bid ?
y
n
cash to bank receive Title
any unsold prop. ?
y
n
unsold Oppor. to bottom of Oppor. deck
sell to bank ?
y
n
see player's manual
sell to player ?
y
n
see p.m.
raze, build ?
y
n
see p.m.
build new building ?
y
n
see p.m.
remod'l ?
y
n
see p.m.
end of year: payoff time
end of game ?
y
n
compute net worth
STOP
advance one year
U-DIG FLOW CHART

Figure 1. U-DIG Game Flow Chart

Figure 2.   Example Sheet of Player's Tables

```
XXXXXXXXXXXXXXXXXXXXXXXXXXX                                                                                          XXXXXXXXXXXXXA
X PURCHASE PRICE    36000 X(20 YR MORTG..80 OF PURCH PR..0675 INT RT)MULTIPLIER     6.818 =PURCHASE PRICE/GROSS INCOME   X   4 UNITS A
X                         X       MORTGAGE (LOAN)              28800   GROSS INC/YR   5280 =RENT 110/U/MO X 4UNITS X12MOS X1.00 OCC F A
X                         X       CASH DOWNPAYMENT        7200         EXPENSES/YR    2218                                XXXXXXXXXXXXXA
X                         X       CLOSING COSTS         + 1800         NET INC/YR BDS 3062
X CASH INVESTED      9000 X                                            DEBT SERV/YR   2666  NOTE. BIT= BEFORE INCOME TAX
XXXXXXXXXXXXXXXXXXXXXXXXXXX                                            CASH FLOW(BIT)  396  NET RATE RET(CASH FLOW BIT/CASH INV) .044

                                                                 ***********                            XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 YEAR   MARKET  EQUITY    EQUITY        INT      NET     NET *   CASH *   TOTAL       NET  INTRNL X  TOTAL        NET  INTRNL  X   AMOUNT
AFTER    VALUE          BUILD UP    PAYMENT   INCOME  INCOME *   FLOW *     TAX        ON    RATE X    TAX         ON    RATE  X   TO PAY
PURCH (+.03/YR)        (PRINCIPAL            TAXABLE     TAX *  AFTER * ON SALE      SALE      OF XON SALE       SALE      OF  X      OFF
                         PAYMENT)                            * INCOME *             AFTER  RETURN X             AFTER  RETURN  X MORTGAGE
                                                             *    TAX *               TAX         X               TAX          X
                                                             *        *   (1.00 X MARKET VALUE)   X     (.90 X MARKET VALUE)   X
                                                             *        *                           X                            X
    1   37080     7922       722       1944      173      52 *    344 *      62      8940    .032 X   -1044      6339   -.257  X    28078
    2   38192     8693       771       1895      252      75 *    321 *     390     10495    .116 X    -469      7536   -.046  X    27307
    3   39338     9515       823       1843      332     100 *    297 *     715     12139    .137 X     106      8814    .029  X    26485
    4   40518    10393       878       1788      416     125 *    272 *    1030     13876    .144 X     428     10432    .070  X    25607
    5   41734    11331       937       1728      502     150 *    246 *    1355     15710    .145 X     729     12163    .092  X    24669
    6   42986    12332      1001       1665      591     177 *    219 *    1671     17647    .144 X    1026     13993    .104  X    23668
    7   44275    13400      1068       1596      684     205 *    191 *    1985     19690    .142 X    1321     15927    .110  X    22600
    8   45604    14540      1140       1526      780     234 *    162 *    2298     21846    .139 X    1614     17970    .113  X    21460
    9   46972    15758      1217       1449      880     264 *    132 *    2601     24128    .136 X    1897     20136    .115  X    20242
   10   48381    17057      1300       1366      986     296 *    101 *    2901     26537    .133 X    2175     22425    .115  X    18943
NOTE. FEDERAL INCOME TAX BRACKET=.30                             ***********                            XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Example Sheet of Player's Tables

for the following:

a) Collecting rent for the year, accounting for a vacancy factor.
b) Paying all expenses, property taxes and normal maintenance.
c) Paying mortgage debt service.
d) Paying the income tax; everyone is assumed to be in the 30% bracket due to his other income.

The "cash flow after income tax" (see Figure 2) for each holding is written on the pay-off sheet. For each vacant lot -$100.00 tax is entered. The cash on hand is counted and five per cent is added on the pay-off sheet to simulate the bank interest for this amount in deposit. The cash flows, vacant lot tax and the five percent of cash on hand are summed. This amount is drawn from the bank as the pay-off for the year.

Then the next year starts with another two rolls of the die to determine the new interest rate and occupancy rate for the year. The procedure noted above is reiterated for each year until the agreed on final year.

To terminate the game, each team liquidates his holdings. His net worth is the sum of his cash on hand and the net on sale after taxes (assuming a sale at 100% of market value) and $10,000.00 for each vacant lot.

Money may be borrowed from other teams at whatever arrangement is agreed upon. The bank will lend up to one-half of the team's net worth at ten per cent per year net interest with the principal amount due in three years.

Any player can refinance by taking the following steps:

a) Paying 2% of purchase price as a refinancing charge.
b) Receiving equity (not market value of equity) at the year of refinancing.
c) At the current interest rate, the player pays "cash down"(see Figure 2) (not "cash required") for the same purchase price and thus establishes the new loan and a new "year of purchase".

Players can sell to each other in the following manner:

a) Negotiate in terms of the price that was paid for the property. Example: "I will offer you $2,000.00 more than you paid, or $36,000.00 plus $2,000.00." Here +$2,000.00 is the difference.
b) When agreement is reached, the seller sells his property to the bank and receives the "net on sale" and pays the bank 15% of the difference, or $300.00 in the example, as tax. The buyer pays the seller the difference of $2,000.00 in the example and buys the property from the bank at the current interest rate.

At any time a team may ask the bank for an offering price on any of the team's property. The banker or game operator will roll the die. If the die shows three or less the bank will offer 90% of market value. If the die shows greater than three, the bank offers to purchase the property at 100% of market value. This offer remains valid until the end of the year. The "net on sale after taxes" as noted in the player's tables (see Figure 2) is paid by the bank and the property is placed at the bottom of the deck of opportunities. The market value of vacant lots here is also $10,000.00.

The game was designed to simulate conditions in January 1969 in the Berkeley, Albany, El Cerrito, California areas. The federal income tax procedures applicable at that time are reflected in the tables. (The federal income tax was updated to reflect changes of the 1969 federal tax law.)

Photo 1

Photo 1 illustrates a game session of Version One in game year seven.

Version Two, the mega-neighborhood version, can either be started at the beginning of a new playing session or Version One can be switched to Version

Two in the same playing session. At the start of this new version a news item is distributed that announces the legislature has eliminated property lines that divide individual vacant lots and the owner of each one becomes the owner of a proportional "share" of the entire block containing the lot. Owners of existing buildings become owners in the new arrangement if they first raze their building. Each owner of one "share" of the common block may choose to construct the number of units equal to the same density anywhere on the common block as in Version One. He may build over any existing white or new structure. His design or placement of the blocks is constrained by rules that mean to assure maximum open ground space, light and air to each unit. See Photo 2.

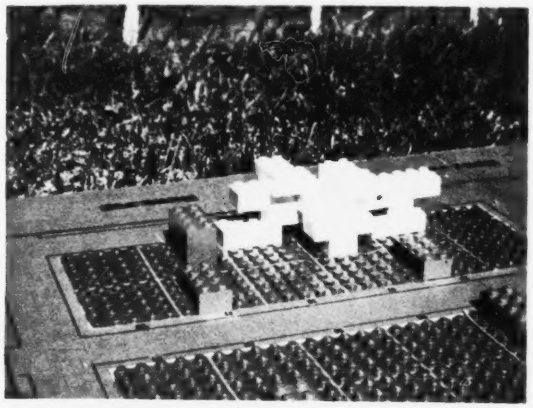

Photo 2 Version Two

On the third level and sixth level the blocks are required to be continuous and cross over the streets at the middle of each side of the block. This simulates a continuous "street" or passageway for neighborhood access. The assumption is made that each Leggo block represents a modular unit that structurally and utility-wise is able to expand in any direction. In this version, the rules of mega-neighborhood can be discussed and modified in order to improve the quality of living.

Assumptions

Assumptions made in the design of the game were:

a) There are no raises in rents unless the property is remodeled. The assumption is that the rents are in a state of equilibrium. Taxes are also assumed not to raise in order to simplify and contribute to the rent equilibrium.

b) There are a limited number of building types in the neighborhood. A simple expansion of the game is to add stores and offices to be built or purchased using the same prepared tables.

c) There is no waiting interval in new construction or in razing an existing building. (An optional rule is to declare new construction planning in one year and to complete construction in the succeeding year.)

d) There are a limited number of opportunities for purchase that occur each year. The random determination of the purchases simulates the chance circumstances that one team may fortunately have first chance at buying a property at the offering price. An optional means of introducing property for sale is for all property that becomes available to be placed for bid.

e) All purchases and changes in the condition of the property for one year are assumed to occur at the beginning of the year purchased. This assumption is made to simplify the tables and bookkeeping.

f) The pay-off: collecting rent and paying income tax are assumed to be on the last day of the year.

g) Razing of a building is assumed to occur with no time lag. The salvage of the building is assumed to be the only compensation for the razing.

Strategies

Investment or playing strategies can be devised based on the predicted rates of return given in the tables. Some possible strategies are:

a) Investing with little concern for a rate of return much greater than that possible to receive from the cash in the bank.

b) Investing with great discrimination, that is, waiting for the best rate of return which means waiting for the lowest rate of interest in a year of high occupancy.

c) "Trading Up" or always being alert for opportunities that through the sale of older property one can have the same equity in a much larger project.

d) Hoarding cash in order to be secure at a 5% increase each year.
e) Bidding always below offering price, and building and buying most heavily during years with a low interest rate.

Rigorous testing of strategies has not been done. Such testing would require many runs for a period of time to simulate fifteen or twenty years, about ten to fifteen playing hours. In order to test strategies, the game might be programmed so that one person could play the game on a computer time-sharing console. This would return basically to the simulation program modified for input by one person.

It suggests another possible modification of U-DIG; to play with the computer doing the computations during the game. To do so would open up many more options such as, a change in the rent by the owner, bids at any over-minimum price.

Educational Use

The game can be used in a variety of university classes in various ways:

a) A single playing session: to demonstrate a limited number of ideas such as the effect of the financial environment on the forms of the city, or how a mortgage actually functions.
b) Several playing sessions: to demonstrate and experiment with limited modifications of the variables of the game. Version One might be played with different ranges of rents and gross multipliers and interest rates by changing the variable values in the computer program. Version Two could be modified by adding building requirements to provide for many building patterns, such as a diamond shape building in plan that spans three adjacent blocks.
c) The structure might be presented to a class in architecture in a quarter or semester project. The investigation of existing parameters of play (or of construction in real life) would be the assigned task of the students. With the existing conditions outlined, the student's ideas on "ought to be" or revised conditions, can become the basis for new rules to be tested by incorporating them in a game that is then played. The student's basis of investigation would be in four components outlined in the final section of this paper and the development of 'new rules' would be an opportunity (and obligation) to understand their values in order to express them in drawing up the new set of rules. The debates would center around improvement of the "quality of life" and how to attain it.
d) A variation on (c) is to challenge the class to devise a set of minimal rules that would require agreements by players to decide on their own rules, especially on the arrangements allowable in the Version Two game.

In (c) and (d) the class would investigate ways to evaluate the resulting forms. Among the factors of evaluation would be the amount and quality of natural light that is allowed into the various living areas, the density, the amount of open space for play and interaction, and the relationship of areas and activities. As a learning experience, this would tend to focus the attention of the student on the most relavent factors of architecture that relate to the quality of living. As this is done with stylized blocks to represent the building shape, the student thinking is pushed into the conceptual level of design.

In the above, the teacher's role should be a minimal one, with the responsibility for the decisions that affect the environment being on the game decision-maker's shoulders. The board could be rebuilt allowing street and other city patterns to be redesigned and the game would encourage class interaction and critique.

The structure of U-DIG is meant to be flexible in order to provide for innovative learning and research goals.

Future Developments

As a background for considering further developments, the major components of the U-DIG Game are identified.

First, an economic component is represented in the prepared tables and their understanding and use. This is the financial environment of the growth of the community.

Second, a technological component is embodied in the Lego block and its rules of combination. The Lego block represents two dwelling units and a part of a corridor. It is a structurally complete unit that has been designed to be combined as described by the rules of combination. The plumbing, mechanical and other architectural considerations have been assumed to be resolved.

Third, a legal component is the set of rules that parallel the legal requirement affecting the development of the community. It includes the zoning codes, building codes and property ownership laws.

Fourth, a social component is the most evasive one to simulate. Presently it is represented by the attitudes and agreements between players and underlies the other components. In Version Two, the social interaction is increased by the need to coordinate construction in order to consider the quality of living.

Each of these components might be an area of further development:

The economic component is a relatively well-defined area. The tables can be simply altered to change the range of any one or more of the financial variables. Before playing the game in a specific neighborhood, the existing factors can be inputed to make the tables and hence the game's operation more relavent to that neighborhood. Another use of the game is to investigate the effects of government subsidies in privately owned rental dwelling units by printing tables to reflect the subsidy, such as a lowered mortgage rate and a lowered down payment.

The technical component could reflect innovations in building systems. For instance, a newly designed building unit in a hexagonal form could be modeled and used in the game. Its development within the constraints of the game would be the result of decisions by each of the teams.

The legal component may be altered in order to test its effects on the form of the city. Version Two, the mega-neighborhood, is an example of this. The private property lines concept was modified. Property lines were eliminated thus allowing a new building form to emerge. Height, density, open space are other legal requirements that might be modified in order to view the form resulting from a "run" of the game.

The social component is the most ill-defined element as it represents the total diversity of human experience. This area of experiment might include playing of the game by members of a ghetto so that they might not only learn about some of the factors in community development, but also may better understand those unreachable owners of ghetto property so that they may better communicate with them. Coalitions or ways of cooperating to own and develop their community may be run in the game. Innovative means of ownership might be devised and tested.

Combinations of modifications of two or more of the components may be chosen to be studied in the game.

Another direction of the game may be to add more playing components. An enlargement of the number of blocks to a small town with several neighborhoods of different character, a commercial area, public areas, schools, parks, civic buildings, etc. Politicians, planners, school officials, architects and others involved in decisions that affect the form of the city might be added. In order to simulate the formulation and operation of zoning laws, a limited functioning planning commission and city council might be added.

U-DIG, the study of an urban process, is never ending. The game is a tool to help in the understanding of parts of the urban labyrinth.

DEVELOPMENTS IN SCIENTIFIC APPLICATION OF PHOTOGRAMMETRY TO STUDY OF ARCHITECTURE AND BUILDING SCIENCE

Perry E. Borchers

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Abstract

Recent applications of photogrammetry in this country and abroad include the rebuilding of demolished structure on the basis of photogrammetric drawings, the drawing of whole street facades in historic areas to judge the effect of proposed architectural additions, the study of structural deformations, and the recording of such elusive forms as soap film membranes as models in the structural design process.

Background

Photogrammetry is a highly developed science of measurement by means of photography providing geometrical data for basic research. The history of photogrammetry goes back more than 100 years to the pioneer work of Laussedat in France and of Meydenbauer in Germany.

The geometries of photogrammetry and of architecture coincide at several levels: the geometry

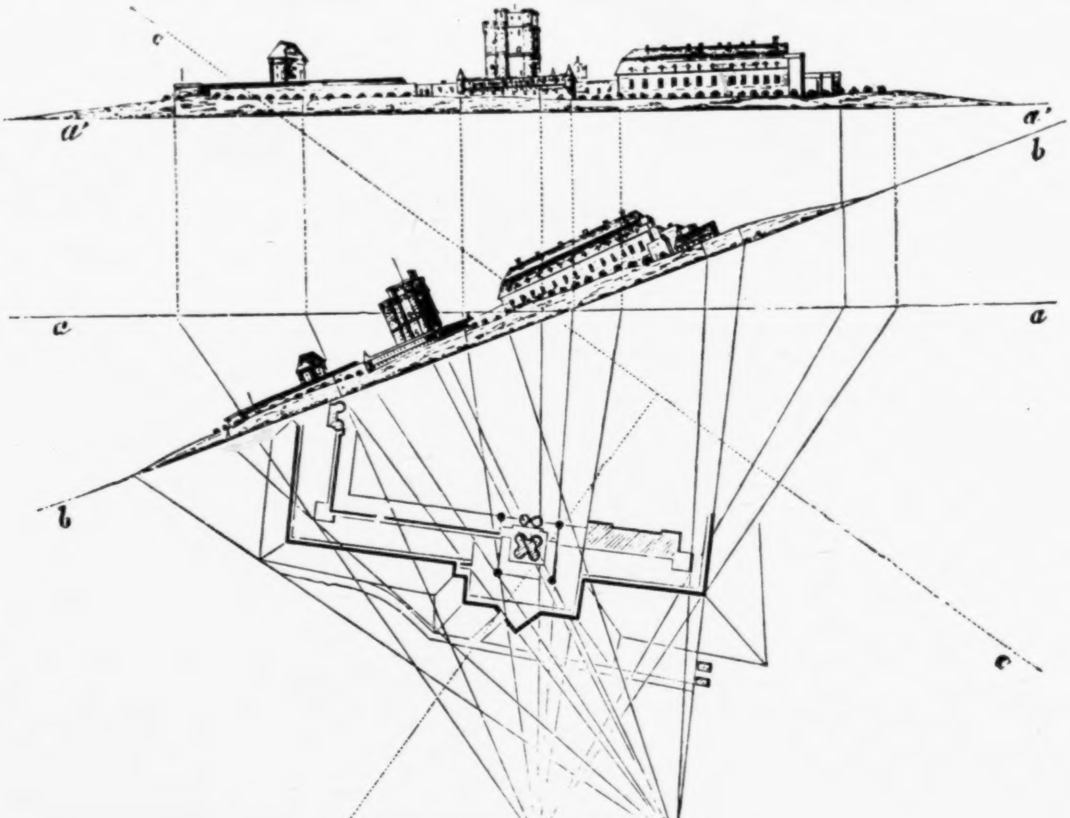

Figure 1. Chateau de Vincennes on the outskirts of Paris, A. Laussedat 1850. (1) Survey made by graphic system of intersecting lines of sight, using perspective views obtained with a sketchmaster.

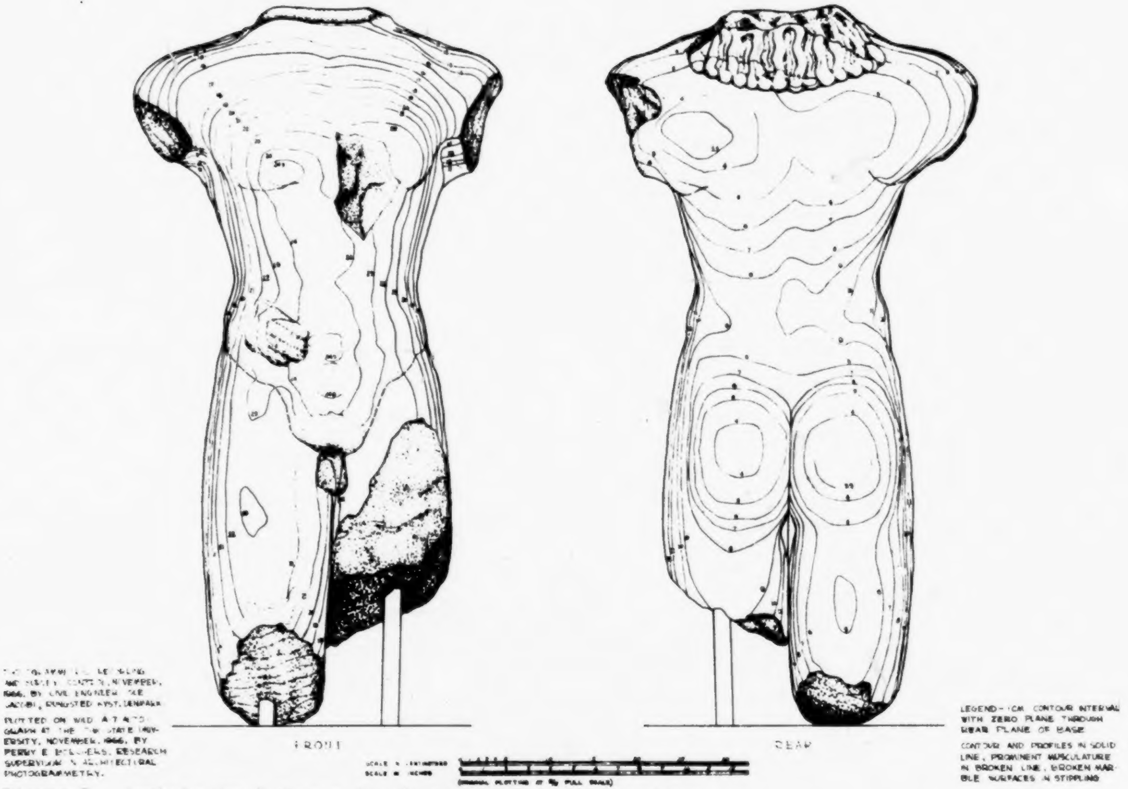
PLOTTED ON WILD A7 AUTOGRAPH AT THE OHIO STATE UNIVERSITY, NOVEMBER, 1966, BY PERRY E. BORCHERS, RESEARCH SUPERVISOR IN ARCHITECTURAL PHOTOGRAMMETRY.
FRONT
REAR
SCALE IN CENTIMETERS
SCALE IN INCHES
LEGEND - 1CM CONTOUR INTERVAL WITH ZERO PLANE THROUGH REAR PLANE OF BASE
CONTOURS AND PROFILES IN SOLID LINE, PROMINENT MUSCULATURE IN BROKEN LINE, BROKEN MARBLE SURFACES IN STIPPLING

Figure 2. Archaic Greek Kouros in Glyptothek Museum, Copenhagen.
Plotted and drawn at The Ohio State University from photogrammetric plates sent from Denmark, 1966. (2)

of central projection in photography and in architectural perspective; the geometry of stereophotogrammetry and of binocular visual perception of architecture and space; the geometry of orthographic architectural drawing and of rectangular coordinate systems in space, photogrammetric plotting and orthoprinting. Analytical photogrammetry and architectural computer graphics are based on similar formulas, except that photogrammetry, dealing with accuracy limitations of the eye, lenses, plates, emulsions and instruments, has a developed theory of error and adjustment computations.

Depth dimensions and the contours expressing depth in drawing are readily accessible data in photogrammetric plotting; and photogrammetric drawings which contain both planimetric detail and contours are more complete in the expression of geometric data than orthographic architectural drawings, even with their conventions as to weight of line and outline. Architectural forms which were freed from rectangularity to become sculptural and innovative in structure have required photogrammetric means to record and photogrammetric contour drawing to express their geometry. Construction drawings of complex architectural models recorded photogrammetrically have appeared like topographic maps.

The photographic plates which - with survey control - constitute the initial photogrammetric record carry a degree of detail, particularly of surface texture, which exceeds that which can be drawn. Limitations on the reproduction of photographs in this paper prevent a properly-balanced illustration of photogrammetric methods and resources - of photogrammetric plates with fiducial marks to determine the principal point in the image, of stereopairs as three dimensional illustration in technical publications, of rectification and orthoprinting. These last are means of converting the geometry of central projection in the photograph to the geometry of orthographic projection with the least loss of photographic detail and the least intervention (and cost) of plotting machine operators and draftsmen.

Photogrammetric Plates and Survey Control

The photogrammetric plate - with its survey control of camera positions, camera orientation and selected elements within object space in the photographic image - contains all the information which can later be abstracted in drawing or as coordinate data. It is the first record, limiting all future records according to the extent of photographic coverage, accuracy and geometric distribution of survey control in the photographic image, accuracy of calibration of camera body and lens, and flatness and quality of resolution of the photographic emulsion. All of these matters are subjects of continuing research and improvement in the profession of photogrammetry.

The typical photogrammetric cameras for architectural surveys are phototheodolities - mounting a precise camera upon a surveying instrument - or stereocameras with fixed bases between two cameras for simultaneous photographic exposures. The cameras have rigid bodies to maintain the geometry of interior orientation and fiducial marks recorded on the photogrammetric plate to establish the principal point of the image, i.e., the intersection with the image plane of a perpendicular line through the center of the lens, ideally the camera axis. Recently, less expensive cameras than those especially built for photogrammetric use by major instrument manufacturers within Europe such as Wild, Zeiss, Officine Galileo, Poivilliers and others, have been adapted for close range and terrestrial photogrammetry - among which architectural surveys are included - by calibration in photogrammetric institutes, by addition to the camera body of fiducial marks to establish the principal point in the image, by the addition of glass plates against which to flatten the photographic film - sometimes with reseau markings to determine film warping at the time of exposure and later, and by determination of distortion in the lens as a means of knowing the error in subsequent analogue plotting or of compensating for error in the image coordinates in computer programs of analytical photogrammetry. Rollei and Hasselblad cameras are among those adapted in this manner to fix the interior orientation. The elements of exterior orientation, i.e., the space coordinates of the camera position, the orientation angle and tilt of the camera axis and the rotation of the image plane around the camera axis, must then be determined by separate surveying instruments or by computation of lines of sight from elements of survey control targeted in object space and recorded in the photographic image.

When photogrammetric plates and films are taken as stereopairs, i.e., along generally parallel camera axes with the camera stations displaced on a line generally perpendicular to the camera axes, there is the advantage of stereoscopic viewing of an optical model. This reproduces binocular vision in object space with increased acuity of depth perception because of a greater base in photography than that which separates the human eyes. For architects and craftsmen associated with architectural restorations the stereopairs directly viewed can be the most impressive element in the photogrammetric process.

Photogrammetric stereopairs with their survey control can be transmitted in space - Figure 2, or consulted after the lapse of time - Figure 3, drawn in 1970 from plates taken in 1963. The proposed rebuilding of the great entrance arch of the Old Chicago Stock Exchange by the city of Chicago means that these plates will be plotted and drawn again in 1972.

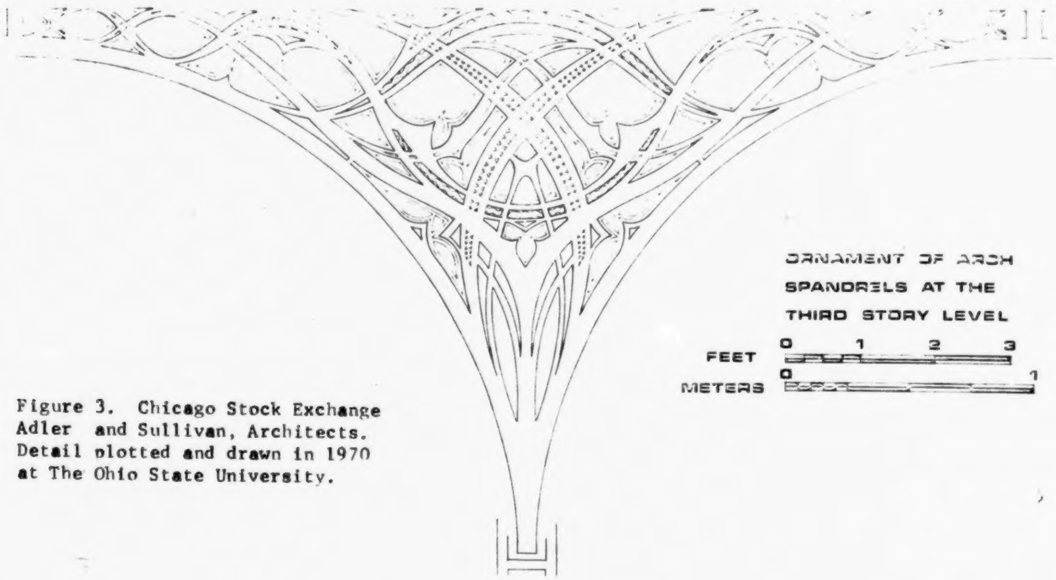

Figure 3. Chicago Stock Exchange
Adler and Sullivan, Architects.
Detail plotted and drawn in 1970
at The Ohio State University.

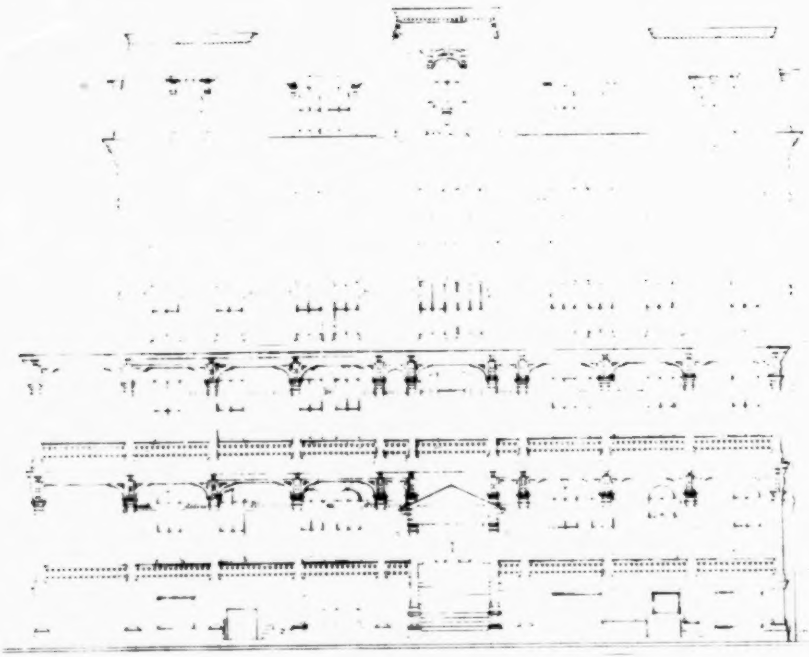

Figure 4. South Elevation of the Pavilion Hotel, Montpelier, Vermont.
Part of the State of Vermont Capital Complex, Robert Burley and Associates, Architect
Recorded photogrammetrically 1969 and drawn at The Ohio State University 1970.

Photogrammetry in the Rebuilding of Demolished Structure 1969-1971

Historic architecture has been the chief subject of architectural photogrammetry, and imminent demolition has been the chief spur to photogrammetric recording of US architecture. Since 1956, more than 30 contract projects in architectural photogrammetry have been carried out at The Ohio State University, recording some 70 historic buildings and engineering structures, chiefly for the Historic American Buildings Survey and the Historic American Engineering Record of the National Park Service, U.S. Department of the Interior, and preparing more than 150 sheets of drawings. Complementing the National Park Service summer program of hand measurement by teams of student architects, photogrammetry has been the most efficient system for recording structures which are complex, sculptural or deformed, tall, difficult or dangerous of access, or which have little time before demolition. Several historic buildings exist now only in the photogrammetric record of the HABS.

In the fall of 1969, a historic building was recorded for the new purpose of rebuilding after demolition. The Pavilion Hotel in Montpelier, Vermont, was part of the State Capital Complex planned by Robert Burley and Associates; and it was scheduled for gutting and rebuilding of new state offices within its outer walls, when the contractor, the Pizzigalli Construction Company, bid half a million dollars less to demolish the building entirely and rebuild the outer walls as well as the inner core. On short notice, an OSU photogrammetric team recorded the outer walls before demolition in October 1969; the stereopairs were plotted and drafted at OSU during the winter in time to help guide rebuilding in the spring of 1970. A print of the drawing in Figure 4 was prominently displayed at the front of the construction site during the work, which is now complete.

The general accuracy of photogrammetric plotting in projects of this kinds, based on residual discrepancies at survey control points chiefly located in the plane of the camera horizon, is to within about 1/1000th of major dimensions. The vertical dimensions of the Pavilion Hotel were evened off to eliminate sags and broken masonry, easily measurable in the stereopairs and evidence of uneven foundation settlement. (The rebuilding was moved ten feet on the site.)

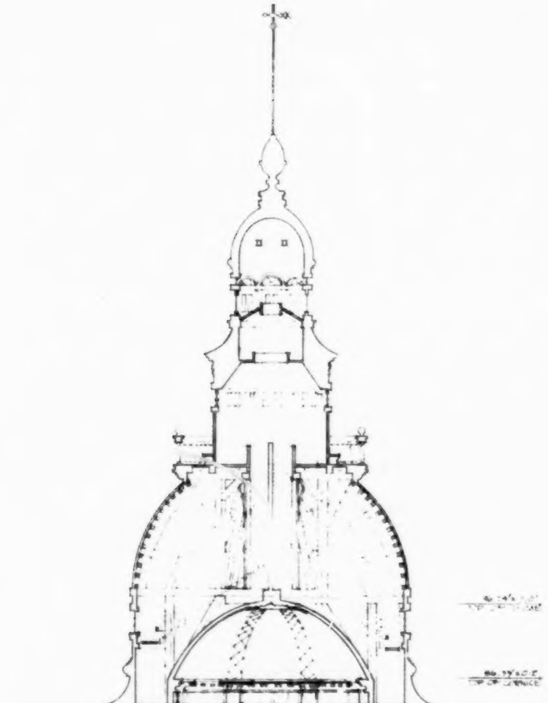

Figure 5. Old Statehouse, Annapolis, Maryland. Section through the rotunda and cupola recorded photogrammetrically 1970 and plotted and drawn at The Ohio State University 1970 71.

Again, in November 1971, a photogrammetric recording was made in haste of the Exchange Room of the Old Chicago Stock Exchange by Adler and Sullivan, 1893, when demolition revealed a false ceiling and uncovered original Sullivan plaster, stained glass and stenciled ornament which the Art Institute of Chicago is determined to restore in a museum room of the original dimensions as measured by photogrammetry.

Photogrammetry in Historic Preservation

Among photogrammetric projects concerned with the preservation of historic architecture the most recent at The Ohio State University has been the recording of the rotunda and cupola of the Old Statehouse in Annapolis, Maryland, in which George Washington resigned his commission as general of the Continental Army in 1784. Government buildings in Maryland had been the targets of bombing; and this historic building was well-guarded at the time of photogrammetric recording of its heavy timber structure.

Figure 5 is a section through the rotunda and cupola of the Old Statehouse. This drawing was assembled from plottings and measurement of the following stereopairs:

> From camera stations upon a rooftop at close quarters to the octagonal cupola, stereopairs of the exterior side facade with horizontal camera axes and then with camera axes inclined upwards 24°, with manual measurements upon the building serving as survey control.
>
> From camera stations in the interior - tripods at ground floor level of the rotunda - stereopairs of the interior walls with horizontal camera axes and then with camera axes inclined upwards 18°, with camera horizon markings upon the walls and columns serving as survey control.
>
> Finally, with the photogrammetric camera removed from its theodolite base and laid with plateholder back upon the floor and lens pointed upwards, a stereopair up the tall and narrow interior of the cupola, with nearly vertical camera axes, and survey control consisting of two measuring tapes stretched at right angles to each other horizontally across the cupola between windows at its mid-height and - establishing a positive vertical coordinate axis in object space - a weighted measuring tape hanging from mid-height in the cupola to the floor upon which the camera was resting.

Spaces and structural elements between interior and exterior domes were recorded in film stereopairs with the Hasselblad Supreme Wide Angle camera. The control provided by major dimensions from the plotting of phototheodolite stereopairs together with a few additional dimensions for scale sufficed for completing the drawing.

Photogrammetric Instrumentation

Besides phototheodolites and stereocameras another group of photogrammetric instruments are those used to abstract the data recorded on the photogrammetric plates. The simplest are stereoscopes with parallax bars for direct measurement and rectifiers for projection. Then there are mono- and stereocomparators of varying degrees of electronic coordinate readout, analogue plotting instruments of special or universal application, orthoprinters, and automatic and analytical plotters programmed with computers. Each of these instruments has an appropriate and efficient application in architectural photogrammetry according to varying requirements of accuracy, speed of data production, adaptability to routine or to diversity of use, and skill demanded of the operator.

Pocket and mirror stereoscopes with parallax bars are easily portable instruments for viewing stereopairs as optical models and for taking off measurements of horizontal parallaxes from which depth in space and scale of dimensions can be calculated with rough accuracy.

Rectifiers are precision enlargers with rotating and tilting projection tables on which the true orthographic proportions of an architectural plane can be reestablished and printed when the inclination and angles of the camera axis in relation to the architectural plane during the photography are reproduced in the rectifier. "Single-picture photogrammetry" was the early name for this process, providing satisfactory accuracy and exceptional detail of surface texture, masonry joints, stained glass, mosaic and fresco on essentially plane surfaces. Distortion appears in the projected image for all elements before or behind the rectified plane, requiring another method of correction.

Mono- and stereocomparators are instruments - sometimes of the highest order of accuracy with electronic and tape readout - for the measurement of image coordinates as data for calculation of object-space coordinates. Stereocomparators allow the simultaneous measurement of image coordinates in one photogrammetric plate and x and y parallax in a second plate, and are the most effective instruments for the measurement of structural deformations and small building movements. Both mono- and stereocomparators can be used in the process known as analytical (or computational) photogrammetry.

Analogue plotting instruments use stereopairs to recreate optical models - by projection or by mechanical means - through which an operator can move a measuring mark, touching elements and simultaneously drawing them in orthographic projection. This is stereophotogrammetry. The Ohio State University has a Wild A7 Autograph analogue universal plotting instrument of first order accuracy. It can accept plates from photogrammetric cameras of varying focal lengths. All the elements of exterior orientation can be adjusted with a greater accuracy than that recorded by the phototheodolite. It can be used to plot both aerial and terrestrial stereopairs, which means, in architectural photogrammetry, both elevations and horizontal sections and plans can be plotted, or, in the case of the vertical stereopairs upwards under the cupola of the Old Statehouse in Annapolis, both horizontal sections with ceiling plan and vertical sections with interior elevations could be plotted. Gears allow a change of scale of 24 times in the plotting. These are characteristics of a universal plotting instrument, having yet one disadvantage in the skill, particularly in orientation, required of the operator of it.

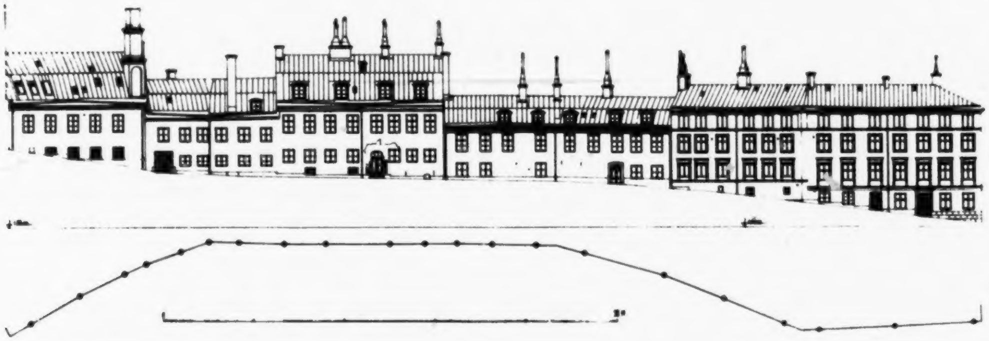

Figure 6. Ten building fronts on a narrow curving street, drawn from analytical photogrammetry at the Royal Institute of Technology, Stockholm Sweden. The lower line shows a traverse of control points in plan. (3)

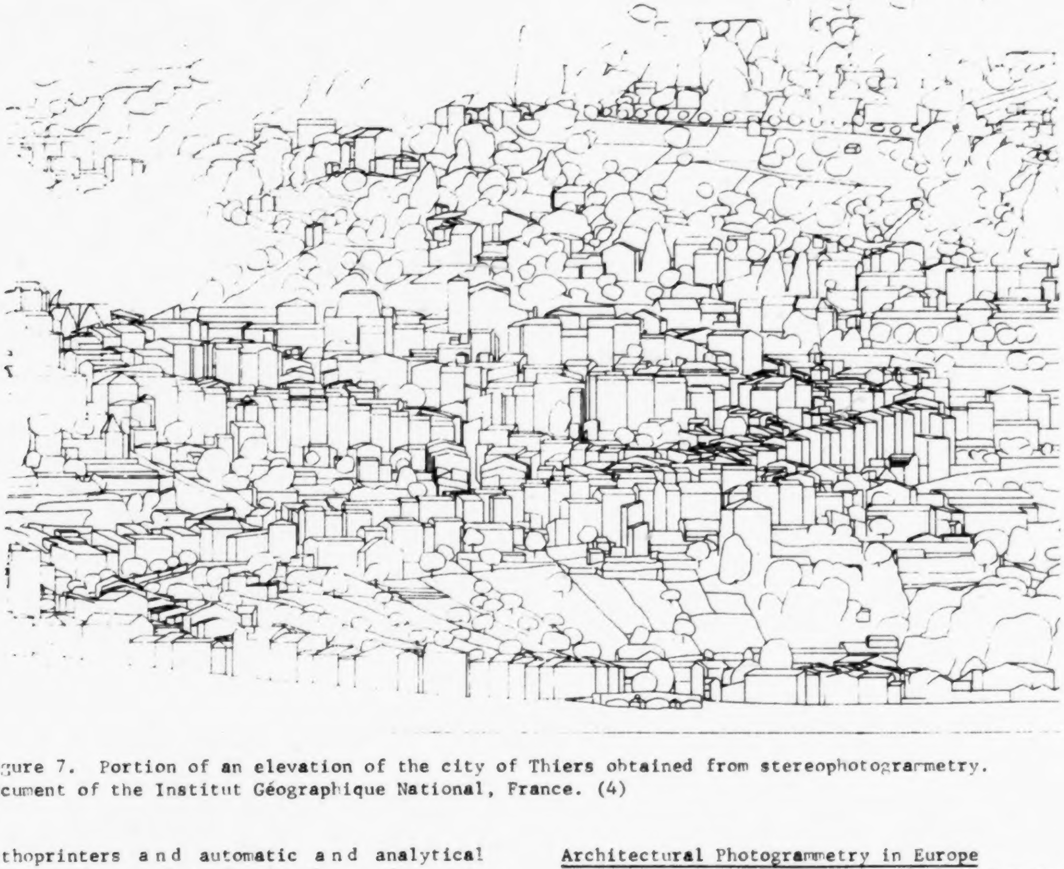

Figure 7. Portion of an elevation of the city of Thiers obtained from stereophotogrammetry. Document of the Institut Géographique National, France. (4)

Orthoprinters and automatic and analytical plotters have been developed to reduce time and reliance on the operator. Orthoprinting produces data from stereophotogrammetry similar to that produced by rectification in single picture photogrammetry. The process requires operator or automatic control of depth in the optical model while the orthoprinter scans and prints photographic data. As yet, no automatic control has been able to compensate for the sudden changes in depth of the architectural optical model and for those planes seen - often in only one image of a stereopair - which should be projected as a line edge in the orthoprint. Automatic and analytical plotters are variously adapted with computers automatically processing image and optical model coordinate data to calculate relative and absolute orientation of the photographic plates, to calculate coordinate data in object space with digital or analogue printout, and to recognize and print contours of depth. The automatic systems still require the discrimination of an operator - perhaps in the future a programmer - to distinguish those features worth recording, i.e., in architecture the wall instead of the ivy.

Architectural Photogrammetry in Europe

There is a much greater use of photogrammetry in Europe than in this country for recording and measuring architectural subjects; and this is particularly evident in the field of preservation of monuments and historic areas. These last - as they have almost ceased to exist in the United States - should be defined as those exterior spaces whose special and pleasing character is established by the coherent but otherwise unexceptional facades of whole blocks and streets and neighborhoods of buildings. Under the pressures of the automobile, tourism and economic growth many of these historic areas are being penetrated by new building with an impact on the area which cannot be anticipated without adequate drawings of the present facades in relation to proposed new structures.

Photogrammetric sections have been established in many ministries concerned with the cultural and architectural heritage; and new instruments and techniques are being specially developed for the recording of long facades upon narrow streets. Figure 6 shows a Swedish solution to the problem employing analytical photogrammetry in the measurement of image coordinates in convergent photographs - not stereopairs - angled up and down the street, with computer calculation of coordinates in object space for all major lines of the buildings. (3) In similar street situations throughout Austria another solution was adopted by their Federal Service of Historic Monuments - making stereophotogrammetry routine for relatively unskilled technicians (architects) with standard stereocameras of fixed base and a limited number of inclinations matched with an analogue plotting instrument of similar limitations, allowing productionline drawings from saturation stereophotography at short distances. Among the solutions proposed in France within the National Geographic Institute to the need for extensive street facade drawings has been a class of "expressive" drawings, with allowable errors of as much as 5%, which can be rapidly assembled from the rectification of multiple single photographs.

Photogrammetric Measurement of Building Movement

The application of architectural photogrammetry with the most rigorous requirements of accuracy and greatest diversity in conditions of photography is the recording and measurement of three-dimensional movement in architecture and engineering structure. The main characteristic of photogrammetric measurement of such movement is the abstraction as basic data of relative measurements between pairs of plates photographed at different times with the same camera at the same camera station along the same camera axis. The most efficient instrument of measurement is the stereocomparator. The correspondence between successive pairs of plates, measured together, effectively eliminates systematic error caused by lens defects and makes possible the measurement of movements of structure with greater accuracy than measurement of the structure itself.

Radial error caused by the lack of flatness of photogrammetric plates and emulsions has been the most substantial error in the process, but even this can be corrected by relative measurements, by a system described elsewhere. (5)

With the correction of relative radial error, the standard error of measurement in the photographic image has varied from 1/9000 to 1/50,000 of the width of the image with various photogrammetric cameras used at The Ohio State University and the Royal Institute of Technology in Stockholm. The propagation of this error by projection into object space must be computed to determine the significance of measured data. (see Figure 8) Even thermal sources of struc-

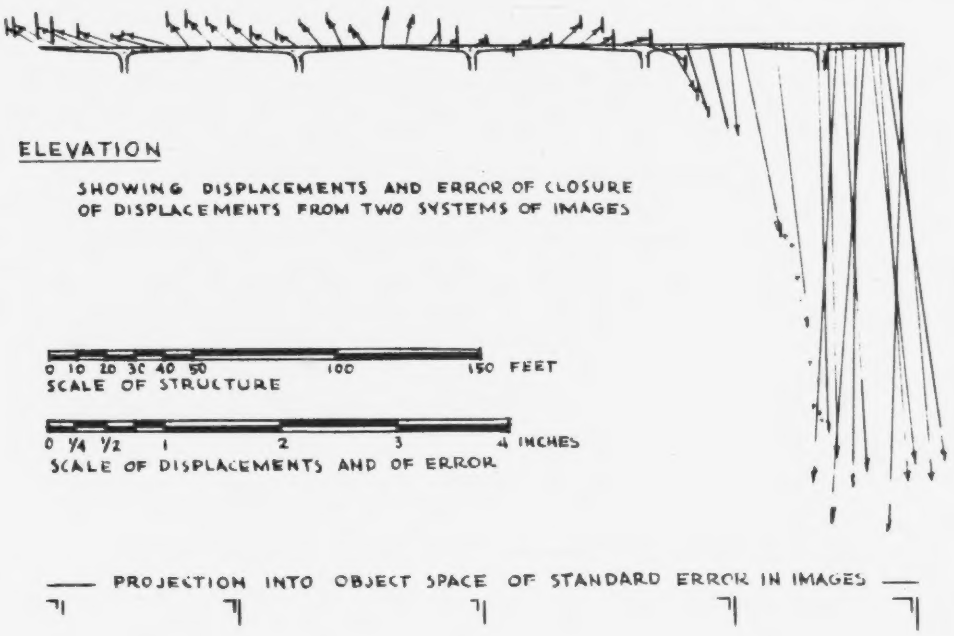
ELEVATION
SHOWING DISPLACEMENTS AND ERROR OF CLOSURE OF DISPLACEMENTS FROM TWO SYSTEMS OF IMAGES
0 10 20 30 40 50 100 150 FEET
SCALE OF STRUCTURE
0 1/4 1/2 1 2 3 4 INCHES
SCALE OF DISPLACEMENTS AND OF ERROR
PROJECTION INTO OBJECT SPACE OF STANDARD ERROR IN IMAGES

Figure 8. Displacement measurements of five hyperbolic paraboloids at Scioto Downs racetrack (5) during curing of concrete of final paraboloid and with change of temperature. Photogrammetric recording and measurement at The Ohio State University and the Royal Institute of Technology, Stockholm, Sweden.

tural movement can be sought photogrammetrically over an entire structure. One of the advantages of photogrammetry in this search is that, recording hundreds of potential measurements in a moment of time, structural movement may be discovered where it was never anticipated.

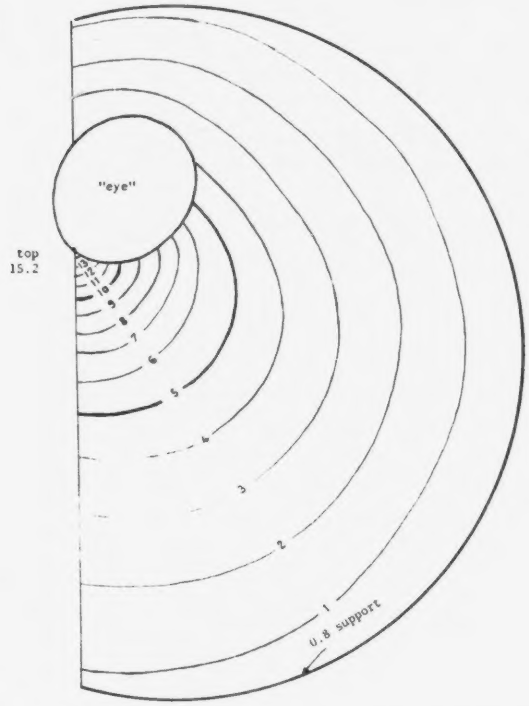

Figure 9. Photogrammetric contour map of the front surface of a soap film membrane with an eccentric "eye" based on a circular support.

Photogrammetry in the Design Process

There has been an earlier account of architects who designed in sculptural model and were unable to dimension their conception for construction drawings until the model had been photographed and plotted in contours by stereophotogrammetry to establish some 1700 locations of reinforcing steel in a concrete shell. ( )

The west German engineer and architect Frei Otto has designed unusual tension structures such as the roof of the German Pavilion at Expo 67 in Montreal from observation of thin soap membranes which he transformed into wire models. At the University of Stuttgart photogrammetric research has now established a method of direct measurement of the unstable soap membrane - which had earlier eluded effective photographic recording because of transparency and near-invisibility and reflections which are never seen stereoscopically in the plane of the reflecting surface. The method, which has been published (6) with results illustrated in Figure 9, was to mix a fluorescent chemical of otherwise neutral characteristics into the soap solution, expose the soap membrane to ultra violet radiation through a screen casting a texture of shadow upon the surface (which elsewhere emitted low energy fluorescent radiation), photograph with stereocameras, measure with a comparator, and evaluate analytically to produce contour maps. This method can now be a part of the design process, as soap films have been studied for over 50 years to solve torsion problems as well as the problems of tension structures.

Summary

Photogrammetry is a science of measurement providing geometric data for basic research in many fields. According to Lord Kelvin -

> When you can measure what you are talking about and express it in numbers you know something about it. When you cannot measure it or express it in numbers your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely attained to the stage of science, whatever the matter may be.

The natural forms of photogrammetric data are particularly appropriate to architectural use. The single photograph can accept the architect's perspective drawing upon it; and the rectified photograph can accept his orthographic elevation. Stereopairs reproduce binocular vision in space, and in combination with orthographic drawings prepared photogrammetrically, allow the most direct comparison of actual dimensions seen in drawings and apparent dimensions seen in space. A theory of error of binocular vision, i.e., of uncertainty of depth perception, can be taken from photogrammetry into architectural space to explain or anticipate the optical illusions which can be exploited or corrected by the architect. (7) Architectural literature could, with great advantage, be illustrated with stereopairs in the manner they appear in the technical literature of photogrammetry.

Photogrammetry and architecture are related as a geometrical science to a geometrical art. The useful applications to architecture of the science of photogrammetry have barely begun to be exploited.

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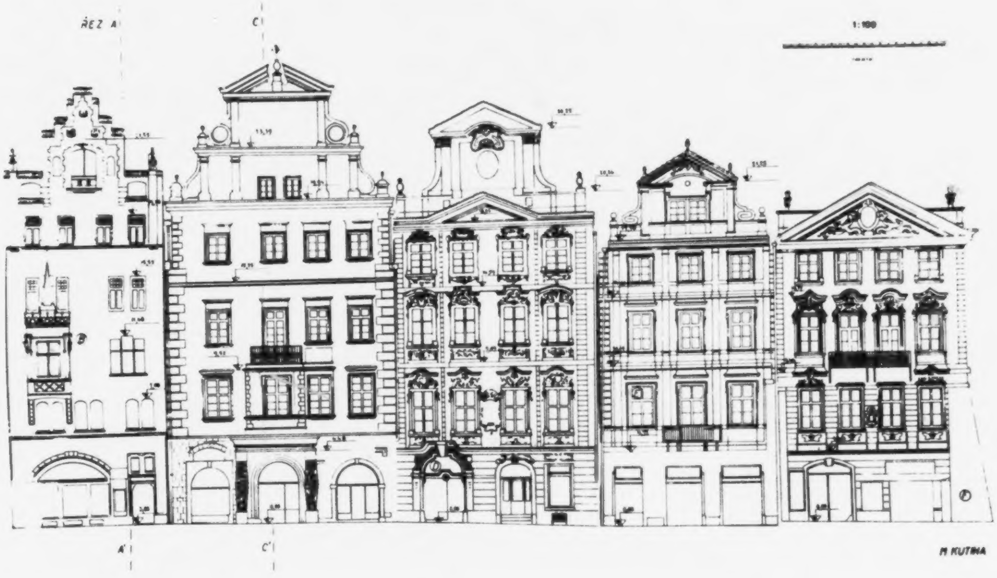

Figure 10. Facades of houses on the main square, Prague, Czechoslovakia, courtesy of the Czechoslovak State Institute for the Protection of Monuments.

AN ANALYTICAL STRUCTURE OF COMMUNITY PUBLIC WORKS DECISION PROCESSES

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A paramount problem which exists in the daily operation of urban planners and public works engineers is the need to accurately structure the resulting community impacts of their capital budgeting investment endeavors, and to be able to trace the evaluation and resolution of these impacts through the political framework.

Inability to do so has widened the gap between the public works professional and the citizen whose quality of life he hopes to improve. Recognition of the significance of this fact has resulted in the legal requirement of demanding an environmental impact statement on all public works endeavors considered likely to have substantial impacts on the adjacent areas to these projects.

This paper addresses the relative lack of theoretical research in these areas relating to the political framework within which community groups evaluate such investments. A structure is presented for considering pertinent aspects of the community decisions on public works problems.

The following are hypothesized on community decisions related to public works project investments:

1. The community decisions are couched in a competitive structure when dealt with in the context of the community political process. That is, different groups have different wants, needs, and perceptions of value related to a physical or engineering alteration of a public works project. These groups may be in conflict with each other and each may initially strive to impose its own interests and demands. (1)

2. Groups are able to articulate these value structures, and often vocally do so in the public hearing process. Further, if modifications in costs, impacts and consequences of design are made and presented to them, they are able to respond to such modifications in a manner consistent with their value structure. (2)

3. It is conceivable that opposing groups, through inflexible stances on alternatives, may bring the implementation to a standstill.

4. To ultimately alleviate this, groups may define a compromise, wherein a realistic give-and-take on the community level results in a final implementation of a public works project of some benefit to all groups. This give-and-take can be roughly captured in the context of "Pareto Optimality," i.e., for one group to gain something, it does so at the other groups' expense, and the possibility of compensating this second group for its loss arises.

5. A series of Federal, state, or local standards relating to each of the several impacts or consequence of each improvement exists, and can be articulated over all potential improvement combinations possible in the entire metropolitan area.

With these assumptions in mind, we are able to formulate the problem by incorporating the following tools of applied mathematics:

A. Linear Programming, which is the optimization of a function of several unknown variables, subject to meeting a series of constraints, also expressed as functions of the unknown variables. (3)

B. Game Theory, which uses information on gains or losses to the community in a competitive decision framework, showing the resulting strategies each group should pressure to accrue a gain, or to insure against a loss. (4)

More formally, for each community interest group k, we model the following:

$$\text{Maximize} \quad \sum_J V_J^k X_J$$

$$\text{Subject to:} \quad \sum_J C_J X_J \leq B_T$$

$$\sum_i \sum_J a_{iJ} X_J \leq T_1$$

$$\vdots$$

$$\sum_i \sum_J a_{iJ} X_J \leq T_m$$

where

X_J = 0 or 1, 0 if a public works project J is not implemented; 1 if project J is implemented

V_J^k = the relative value, weight or emphasis being placed on project J by group k

C_J = project cost

B_T = total capital investment budget for all projects in the area

a_{iJ} = the amount of impact i generated by project J. Using an illustrative example from transportation system investments, there are m such impacts equations, one for each of the following consequences:

system capacity
total accidents, or accidents/MVM
air pollution emission
homes taken
businesses taken
tax dollar loss to the community
business dollar loss to the community

$T_1 \ldots T_m$ = the standards imposed on aggregate community impacts for the total of all implemented improvement projects

The above linear program states that each group will individually emphasize that package of projects in the community which will best fulfill their value structure, subject to meeting budget constraints and aggregate impact levels enforceable as local, state or Federal standards.

However, group k represents only one community pressure group which develops a value structure on packages of capital improvement projects in the community. In general, there are k = n groups of this nature, and their desires are seldom convergent. Hence, competition for implementation of several planning packages emerges, and the result is a competitive strategy across several groups.

Two points are relevant here:

1. When intergroup bartering exists across these n groups, it may be possible to ultimately coalesce the n groups into two final opposing groups with outstanding differences. Carrying this point further, it is possible that these two groups' value structures may be coincident for some impacts, that is, what one group wins, the other loses. The best example of this is two opposing business groups located separately in the community, where, as one group loses a certain monetary amount in business due to changes in the public works investment in the community, the other gains roughly the same amount.
2. More realistically, the opposing groups have highly developed and divergent value structures, and if they each insist on dominating the value system by opposing certain implementation plans entirely, a stand-off can result and no plans will be implemented.

Case I: Like Value Structures on Certain Impacts:

Where the value structure for some subset of impacts is coincidental for the two groups, their individual linear programs can be combined into a zero-sum two-person game which yields the following (3):

$$\text{Expected value} = g = \sum_i \sum_J V_{iJ} X_i Y_J$$

where: $(X_1, X_2, \ldots X_m)$ are the relative weights which planning packages 1...m, are supported in the political process by group 1, where $\sum_i X_i = 1$. This $(X_1^*, X_2^*, \ldots X_m^*)$ is the optimal emphasis if it satisfies the following:

$$\sum_i \sum_J V_{iJ} X_i Y_J \geqslant g = g$$

where g is termed the value of the game, and further, this condition holds for all opposing strategies $(Y_1, \ldots Y_n)$, $\sum_J Y_J = 1$, which is the relative amount of emphasis given to these planning packages by the opposing group. An equivalent optimal planning implementation format for any group A for the above statement, condensed into Linear Programming form is as follows:

Group A:

Let $g = - X_{m+1}$

Minimize $- X_{m+1}$

Subject to:

$$\begin{aligned} &V_{11}X_1 + V_{21}X_2 + \ldots + V_{m1}X_m - X_{m+1} \geq 0 \\ &\vdots \\ &V_{1n}X_1 + V_{2n}X_2 + \ldots + V_{mn}X_{mn} - X_{m+1} \geq 0 \\ &-(X_1 + X_2 + \ldots + X_m) = -1 \\ &X_i \geq 0 \end{aligned}$$

Now the opposing community group B must likewise develop a strategy that insures that it will at least prevent a business loss of an amount g.

As such, a mixed strategy emphasizing planning packages 1...n is developed as the following linear program.

Let $g = - y_{n+1}$

Maximize $- y_{n+1}$

Subject to:

$$\begin{aligned} &a_{11}y_1 + a_{12}y_2 + \ldots + a_{1n}y_n - y_{n+1} \leq 0 \\ &a_{21}y_1 + a_{22}y_2 + \ldots + a_{2n}y_n - y_{n+1} \leq 0 \\ &\vdots \\ &a_{m1}y_1 + a_{m2}y_2 + \ldots + a_{mn}y_n - y_{n+1} \leq 0 \\ &-(y_1 + y_2 + \ldots + y_n) = -1 \end{aligned}$$

This linear programming problem is essentially the dual of the former and the resulting answers are:

$$- X_{m+1} = -y_{n+1} = g = \text{value of the game}$$

and

$$(X_1^*, X_2^*, \ldots X_m^*), \text{ and } (y_1^*, y_2^*, \ldots y_n^*)$$

are developed. That is, g is the most group A can lose, or the minimum that group B can gain by putting forth their optimal emphasis of support on several planning investment options for the community. In addition, $(X_1^* \ldots X_m^*)$ and $(y_1^* \ldots y_n^*)$ are found, which are the optimal emphases that each group should place on supporting planning package 1, planning package 2, etc.

Case II: More Realistic Revision, The Cooperative Game

The above situation is described mainly to show the inherent competitive structure and optimal emphasis of strategies available for the final two groups in conflict. It is quite artifactual due to the restrictive zero-sum concept. We now broaden this to a more realistic process, that of the cooperative game. (4)

This structure assumes that group A finds a value V_A^*, which exists for a package of projects that is optimal to their goals and objectives. It is shown in Figure 1 below. Likewise, group B has a V_B^*, some set of projects, which, if implemented, will optimally fulfill their set of objectives. Each group, through legal potential, community interest, or voting representation may veto the other if it insists on dominating the implementation of its own optimal planning package. This results in the classical stand-off. As such, although initial intergroup bartering has brought n groups into coalescence as two opposing groups, further, final bartering and negotiation may now be necessary to avoid losing the entirety of capital budgeting potential in the community due to the stand-off.

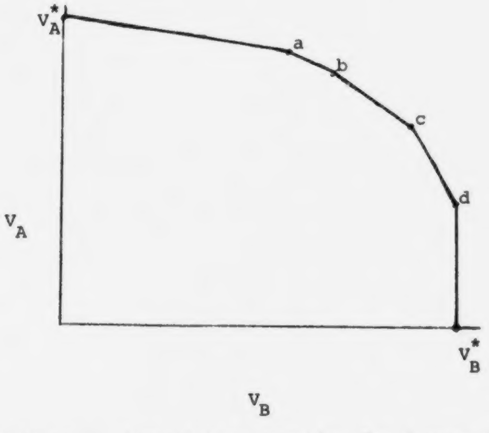

Figure 1. Negotiation Frontier for Groups A and B

The bartering takes place along a frontier of a, b, c, and d, in Figure 1, which demonstrates the classical inherent Pareto Optimality of public works projects. That is, rather than give up the improvement potential entirely, group A is willing to reduce utility level to implement some improvement, even if not optimal for their value structure. Likewise, group B responds by reducing their utility level. As such, a compromise is effected, yielding some $V'^{*} = f(V_A^{*}, V_B^{*})$, a new planning package, in light of compensation to each other's value structure.

This can now be rewritten in our original linear programming structure, as follows:

$$\text{Maximize } Z' = \sum_{J} V'X_J$$

Subject to:

$$\sum_{J} C_J X_T \leq B_T$$

$$\sum_{i}\sum_{J} a_{iJ}X_J \leq T_1$$

$$\begin{matrix} \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \end{matrix}$$

$$\sum_{i}\sum_{J} a_{mJ}X_J \leq T_m$$

which now, through the steps of: a) each group developing their own optimal format; b) comparing it to the competitive nature of the political implementation process; and c) reforming a compromise optimality structure, has allowed tradeoffs across the final opposing groups to be made, within the reconstructed context of community optimality, resulting in a final implementable planning package of public works investments.

Conclusions - Typical Example - Need for Further Research

The fact that communities compromise in planning decisions has been well known for some time. However, inability to structure the dynamics of these compromises has led to policy decisions insensitive to group value structures and ensuing group strategies in the planning implementation process. This paper, with its obvious shortcomings due to mathematical abstraction, requirement of linear functions, and zero-sum two-person game components, is offered as a starting point for structuring the process and initiating a research strategy which would further the potential for casting group value structures and planning implementation within the framework of cost-effectiveness evaluation models of public works project decisions.

In concluding, it is pertinent to note that, in terms of practical application, this conceptual approach has actually been diagrammed for a transportation project in the midwest, which dealt with intersection improvement choices which were held in conflict by two opposing groups, the business component of the community, and a private citizen group concerned with adverse environmental impact. Each group possessed veto power in the community, which, in a standoff, could result in the removal of Federal funding from the area, which was badly congested and required design improvements of some nature. A cooperative game structure, as discussed in Case was attempted and by working across both groups, adequate objective knowledge about impacts, Federal standards, and opposing groups' potential for compromise was articulated. This approach resulted in: 1) a compromise format yielding a value structure, V' compatible to both groups; 2) meeting the budget and design standards; 3) kept Federal funds in the community for improvement; and 4) ultimately allowed a realistic Pareto Optimal solution to be achieved for the community groups involved.

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LIFE3 - THE GAME "LIFE" IN THREE DIMENSIONS

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John Houton Conway's fascinating solitaire game "Life" is normally played on a two dimensional grid with checker-like counters. These counters (organisms) are arranged in a simple starting configuration and any number or pattern may be used. As the "genetic laws" of birth, death, and survival are applied, evolving populations and patterns are observed. Usually the 'game' ends when a governing order is discovered. Often a pattern reaches a point of oscillation whereupon it begins to repeat itself endlessly. Other possibilities include apparent random meandering, growth to complex densities, evolutions to extinction, and various geometric series.

This paper deals with a complex variation of the game that extends the playing field into three-space and uses imaginary cubes as "organisms". This variation removes the game from the physical playground to a mental one, challenging the visualization powers of the participant to the threshold. In this the work is seen as an extension of the author's previous work with close packing spheres and related visualization experiments.

This problem and the related computer techniques closely resemble many investigative processes wherein the aids to understanding the phenomena at hand are specially designed to extend limited human capabilities. This concept is illustrated as this work is treated as a case study of a general problem type. The general category includes any problems wherein the uncovering and description of structural order is tantamount to comprehending the behavioral phenomena.

Because of the analogies with the growth, decay, and alteration of life processes and societies of living organisms the "Life" game study is intriguing. Its greater importance may be in the pursuance of cellular automata theory which is unlocking some of the pattern-recognition mysteries. For the author the challenge lies more in the area of advancing our understanding of human visualization of structural schemes in a dynamic spatial world. The drawings demonstrate that for the study of form and growth processes using computer graphics it is far more efficient to store instructions for generating data than to store the data. Even though we have known this for some years, the "transition function" concept is something of a breakthrough in that it provides a simple way to describe complex geometries. The relationship of this work to those who would pursue the art of creating schemes of order in a spatial world is seen as a most obvious connection.

I. Introduction

This work is largely the fruit of an innocent curiosity spurred by some very simple observations from nature. How is hereditary information and information for growth arranged in the chromosomes of living cells? Can we use what we know about the master molecule DNA and the way it passes hereditary information from one generation to the next in our work in pattern generation using computer graphics? What is locked inside a flower seed? What is the set of carefully constructed pattern codes, and can the solution of the mystery of how they work be helpful to us? So far as my investigation goes, not very much is known about precisely how the genetic information is coded and spelled out to form vital messages. It's clear that however it is done is a superb way of directing patterns of growth to deal with whatever environmental forces await a fledgling organism. In addition to the instructions for normal growth, there are contingency plans, panic strategies, resource-searching algorithms, camouflage directives, and directions for sensitive responses to life-giving energy. All this apparently programmed with an efficiency of instruction coding that humbles the finest human techniques yet discovered for machine process programming. Since the amount of information stored in the genes is much less than the amount needed to describe the structure of the adult organism there is something of an unsolved mystery about the precise coding techniques. One possibility is that the genes carry a set of rules or "transition functions" which are capable of generating the information. The nature of these pattern generators is what is of the most interest here.

Part of the understanding of these pattern codes must follow an understanding of cellular life. Cell division or "replication" is a multiplicative process in net effect, but each cycle leaves in its wake some mutated, some dead, and some weak cells. The point is when a complex array of cells multiplies during a growth cycle, the emergent pattern is formed as a function of the normal cell-splitting system plus a multitude of environmental forces which include radiation, cell density, boundary constraints, energy sources, etc.

The work presented in this paper may or may not have anything whatever to do with organic growth phenomena. My hunch is that it has. It also may or may not have anything whatever to do with an efficient and useful information-coding system for directing environmental growth for humans. At the very least we can demonstrate that we have hit upon an efficient technique for compact definitions of highly complex geometries. It is of particular interest to note that many of the same kinds of curious patterns that we have seen on the plane grid occur in rich variation in three dimensional space.

II. LIFE3 - The Living Environment

In this context the expression "living environment" implies that spatial configurations can be conceived by a staging process in which all the spatial components may develop, change, or cease to exist in an evolutionary manner. At each stage or "generation" the environmental forces(1) determine whether growth may occur and if so, the available locations in space. Two considerations are density limitations and boundary conditions, but other constraints may be applied. The geometric shape of the spatial configurations is then determined by an operative proportional series relating the collection of spatial components. The simplest case is the one to one series for the unit cube.

Each stage then is a responsive and complete assemblage of spatial components which answers the building needs for that period of time preceding the next cycle. Obviously, the cycle time or "generation-scale" may be preset or may be determined by observations of current performance characteristics.

This rather sensible-sounding but idealistic concept is clearly simplistic. If it were a workable idea we would have the basis for truly responsive environments with minimum economic risk. The idea of always having just the amount we need is appealing whatever the context. Nonetheless, these constraints of economy and survival - the law of the jungle - are used in developing the environmental guidance forces for the 3-D cellular automata program called LIFE3.

The objective of the computer program is to develop a technique which will provide a means for directing the evolution of a collective of component spaces. At each stage or generation the grouping will satisfy in number and adjacency the requirements of the project. That is, each stage represents a solution to the organizational requirements for the number of component spaces needed at a particular point in time. Succeeding generations may contain more or fewer component spaces since the transition concept recognizes that "life" doesn't necessarily imply increasing size or increasing density. In fact, one may specify that the final generation contain zero component spaces - i.e., restore the site to its original state. (For example, a building for a world's fair exhibition).

The attempt is to integrate an evolutionary progress of the LIFE3 forms corresponding to a geometric progression within a set of constraining environmental forces. The problem of describing forces is probably the toughest to be faced in the development of this system. It is apparent that normal growth patterns are governed by various forces (stimuli) from within the environment as well as the genetic codes within the cells. The simulation of these forces and codes is what ultimately determines the spatial configurations generated by this program.

The ideas imbedded in the potentialities of three-dimensional cellular automata as space defining systems are far-reaching. It is creatively stimulating to invent new ways that limitations could be imposed on the growth pattern by providing complex boundaries within which the structure is allowed to grow. The generation of a component lying outside this boundary causes a decision to be made which retracts the component and begins the growth in a new direction, according to a predetermined geometric progression or "genetic code". The boundary can then be interpreted as a force of the environment, and the basis for the decision as the structure's "heredity".

It is equally challenging to impose variations on the transition functions which dictate environmental densities of the spatial components. The constraints of the transition functions might be thought of as evolutionary "existence" determinates, while the boundary and progression constraints are the evolutionary "form" determinates.

The LIFE3 program is a modest beginning spurred in part by the above thoughts and in part by the simple curiosity of what Conway's rules would produce if given an added dimension of freedom. The following discussion describes the rather arbitrary method chosen for providing the new dimension.

Consider the 27 cubes of a 3x3x3 array as a cellular unit and the center cube as a nucleus. The nucleus then has 26 "neighbors", 6 face-adjacent cells, 12 edge-adjacent cells, and 8 corner-adjacent cells. The triad units are formed by the nucleus cell and any pair of neighbors. Disallowing rotational identities there are 650 unique ways of arranging the two neighbor cubes around the nucleus. (26 possible positions for the first, times 25 positions for the second). Likewise there are 15,600 ways of arranging three cubes around one and in general 26! ways of arranging 26 cubes around one.

For the triad units we can classify the 650 combinations by considering the interfacing relationships:

Type	Adjacency Combinations for Triad Units	
I	2 common faces	- 6 x 5 = 30
II	2 common corners	- 8 x 7 = 56
III	2 common edges	- 12 x 11 = 132
IV	1 face, 1 corner	- 6 x 8 = 48
	1 corner, 1 face	- 8 x 6 = 48
V	1 face, 1 edge	- 6 x 12 = 72
	1 edge, 1 face	- 12 x 6 = 72
VI	1 corner, 1 edge	- 8 x 12 = 96
	1 edge, 1 corner	- 12 x 8 = 96
		650

The types may then be further classified by noting which combinations are rotationally identical. For example, 24 of the 30 Type I combinations are similar (rotational identities) - thus Type I-A - and the remaining 6 are similar - Type I-B. The subclasses of types for all the triads are shown in Figures 1 - 4.

As a point of departure in studying three-dimensional patterns with LIFE3 each of the 17 triads is used as a beginning configuration. For this particular way of thinking about 3-D cellular automata these 17 patterns represent the simplest possible form generators and provide a basis for inventing other interesting starting configurations. The accompanying Figures 5 through 7 illustrate the first few generations of some of the 17 basic patterns.

III. The Transition Function(2)

The transition function used in generating the configurations shown in Figures 5 through 7 is perhaps the simplest interesting (non-trivial) one yet discovered. There is one cell type - diagramed as a cube - and each cell has twenty-six possible adjacent neighbors. Adjacency is assumed if two cells share either a face, an edge, or a corner. From generation to generation a cell may be either occupied or vacant depending on the preceding configuration and the transition function. If a vacant cell has exactly three adjacent occupied cells, a new cell is established at that location in the succeeding generation. If an occupied cell has exactly two adjacent occupied cells there is no change at that location. Any cell with fewer than two or four or more adjacent occupied cells will be vacant in the succeeding generation.

Summarizing:

1. There is one type of spatial component.
2. Each cell location has 26 neighboring or adjacent cell locations - edge, face, or corner relationships.
3. At each generation every cell is either vacant or occupied by a spatial component.
4. "Death" results from less than two or four or more neighbors.
5. "Survival" of an occupied cell results from two neighbors.
6. "Birth" in a vacant cell results from only exactly three neighbors.

THE 17 TRIAD TYPES

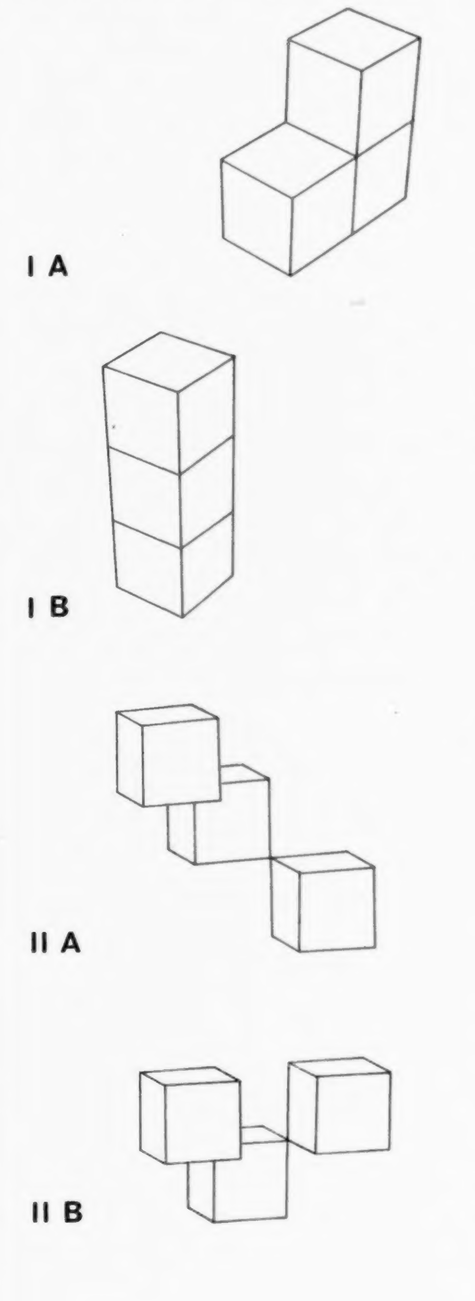

I A
I B
II A
II B

FIGURE 1

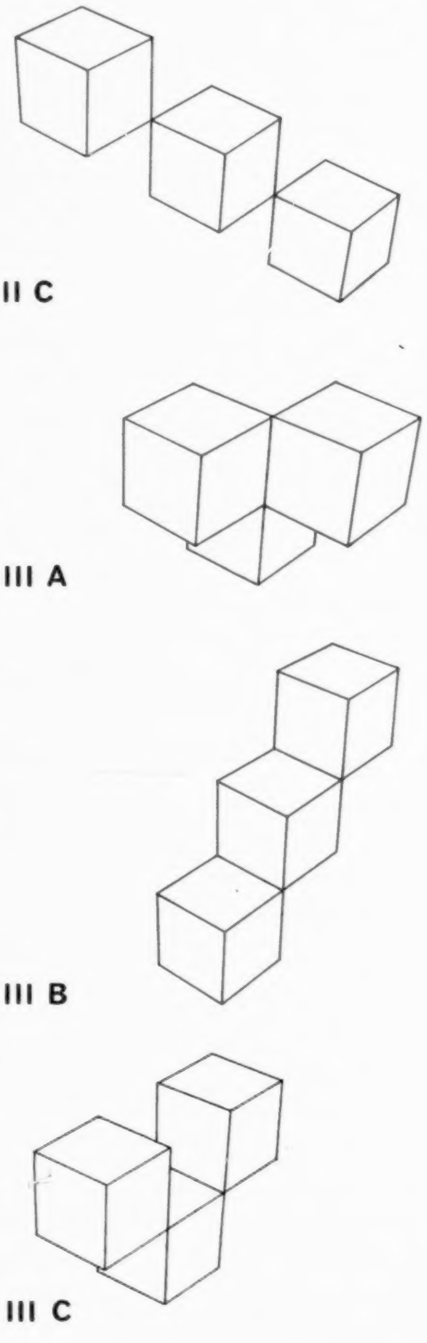
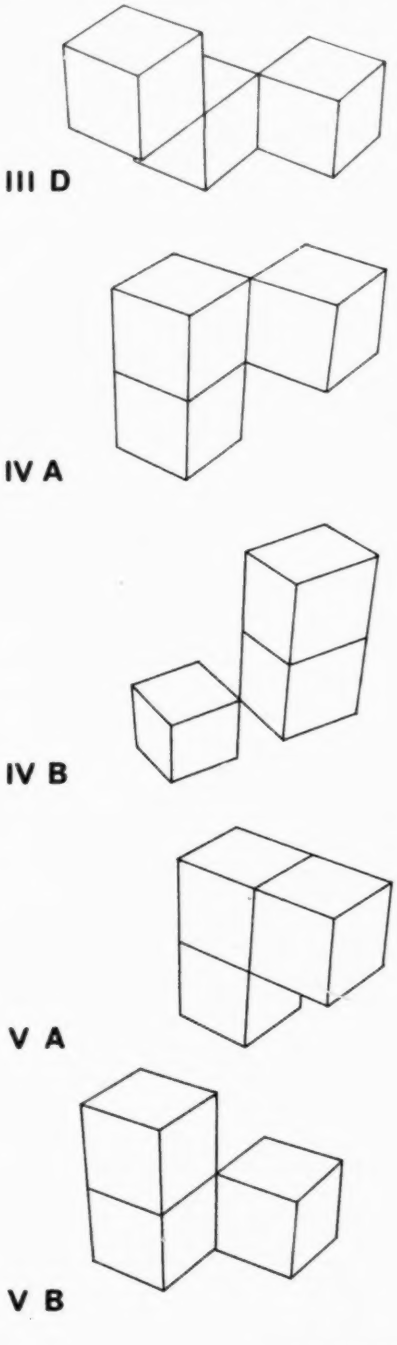

II C
III A
III B
III C

FIGURE 2



III D

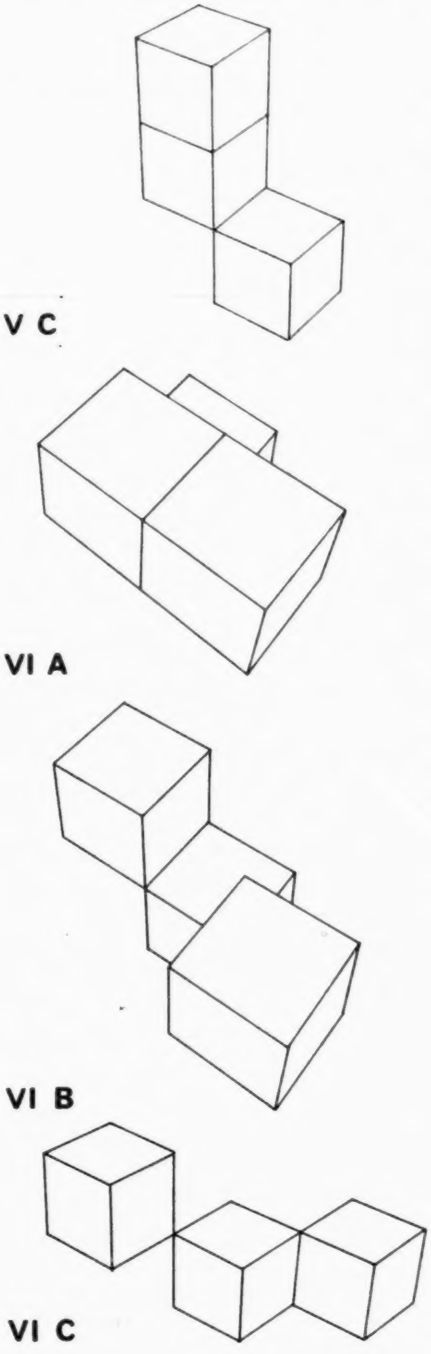
IV A

IV B

V A

V B

FIGURE 3



V C

VI A

VI B

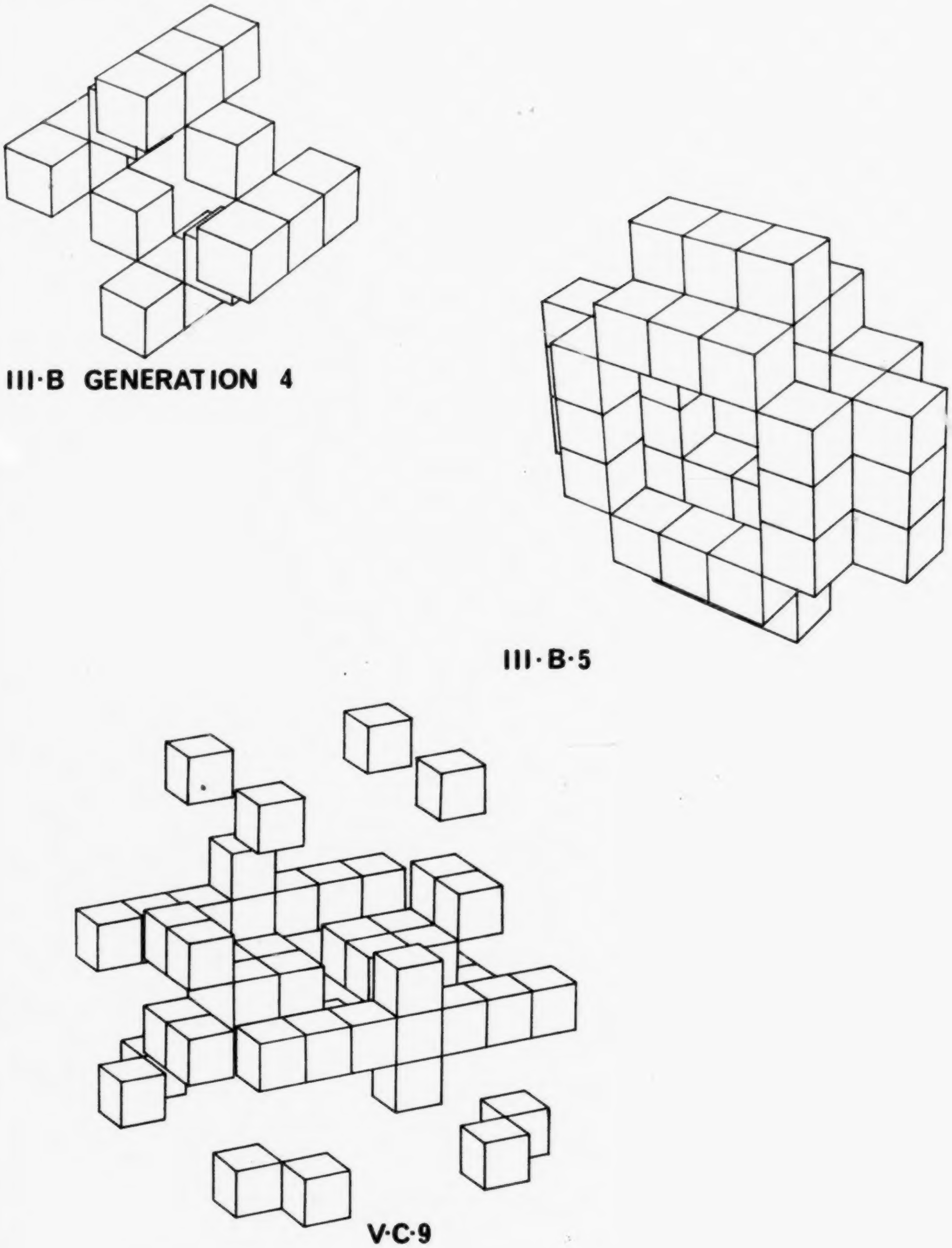
VI C

FIGURE 4

SUMMARY OF CONFIGURATIONS GENERATED BY TRIAD GROUPS

TRIAD TYPE	POPULATION COUNT FOR SUCCESSIVE GENERATIONS										
	1	2	3	4	5	6	7	8	9	10	11
I-A	3	12	4	0	Ends with a square pattern of 4 isolated cells						
I-B	3	9	16	36	62	60	96	74	74 ⟶		
II-A	3	2	0		Ends in a 1 x 2 box						
II-B	3	4	4		Stable 2 x 2 box						
II-C	3	0			Only non-generating triad						
III-A	3	8	0		Ends in 2 x 2 x 2 cube						
III-B	3	3	9	16	36	62	60 ⟶				
III-C	3	6	10	18	38	58	54	120 ⟶			
III-D	3	4	4		Stable 2 x 2 box						
IV-A	3	8	0		Ends in 2 x 2 x 2 cube						
IV-B	3	4	4		Stable 2 x 2 box						
V-A	3	12	4	0	Ends with a square pattern of 4 isolated cells						
V-B	3	8	0		Ends in 2 x 2 x 2 cube						
V-C	3	6	10	18	38	58	54	120	44	76 ⟶	
VI-A	3	8	0		Ends in 2 x 2 x 2 cube						
VI-B	3	4	4		Stable 2 x 2 box						
VI-C	3	2	0		Ends in a 1 x 2 box						

Note that the progressions I-B and III-B yield identical populations and similar configurations with the exception that III-C lags by one generation. As you might suspect, generation 2 of III-B is similar to the triad I-B but rotated 90 degrees. That is, III-B "digresses" to I-B and proceeds to grow with each generation turned 90 degrees. It might be interesting to compare the two with different "environmental forces"--a little like splitting twins at birth. A similar situation occurs with triads III-C and V-C but there is no generation lag.

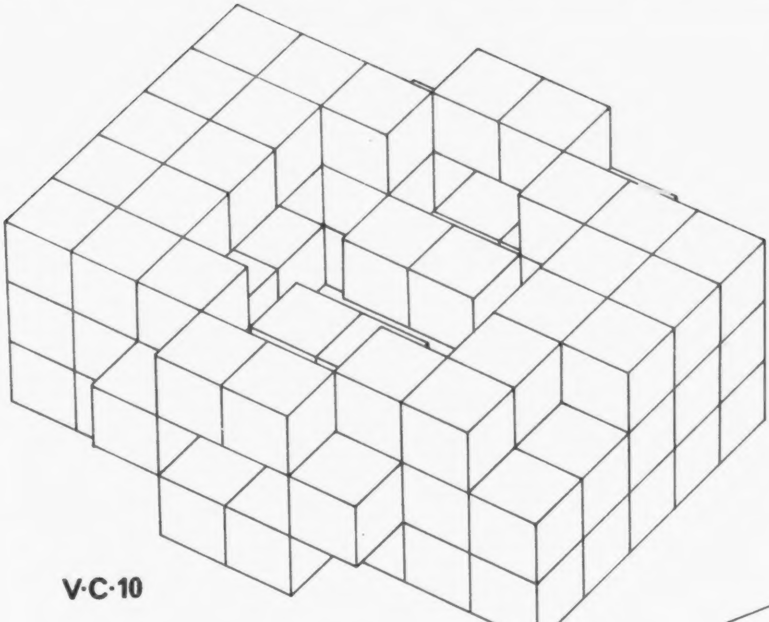


III·B GENERATION 4

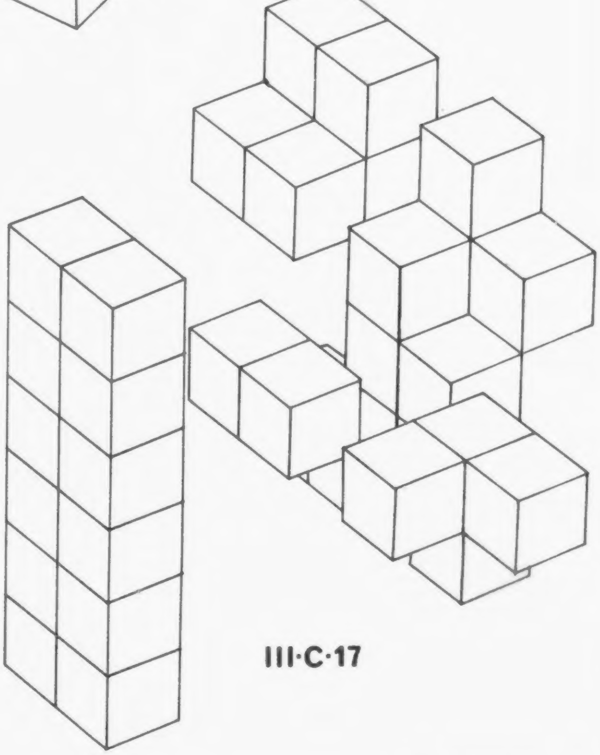
III·B·5

V·C·9

FIGURE 5

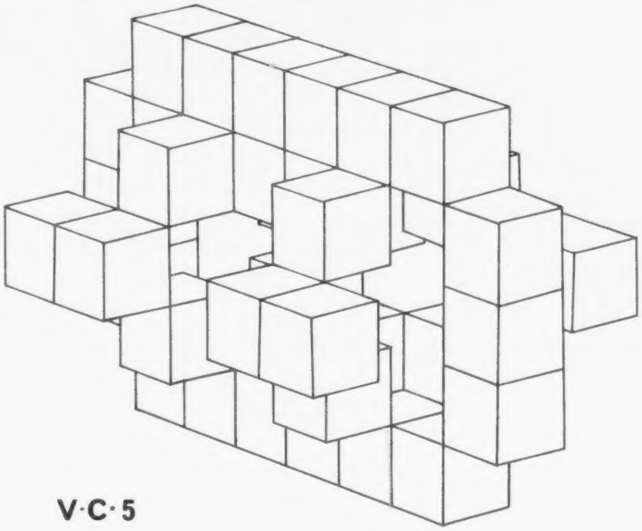


V·C·10

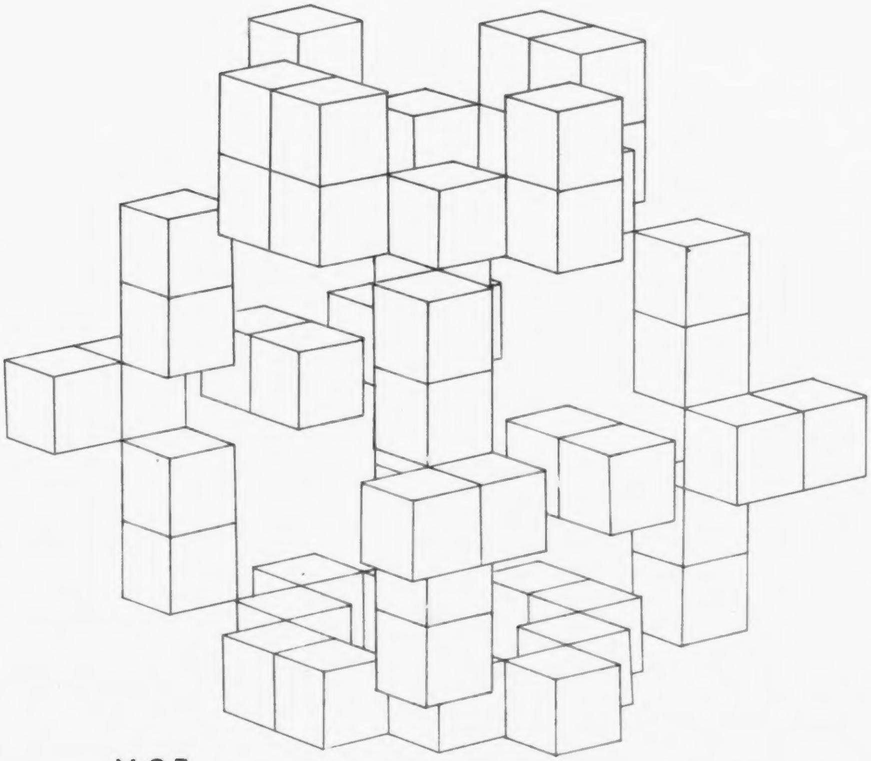


III·C·17

FIGURE 6



V·C·5



V·C·7

FIGURE 7

Concluding Remarks

Thinking, feeling, striving, man is what Pierre Teilhard de Chardin called "the ascending arrow of the great biological synthesis." It may be that the ultimate romanticism is to imagine that understanding the most fundamental life process may also contribute to our understanding of how to design and manage our physical environment in order to maintain the "ascent". To some degree man has already altered himself by altering his environment through such things as radioactive fallout, chemical contamination and social crowding. Is it so far fetched to think that we might learn a great deal about how to structure our living environments by understanding growing and thriving environments at other scales? Just look through an electron microscope! The analogies are so tempting that it is difficult to avoid gross over-simplifications of highly complex phenomena.

This collection of ideas and techniques supports four major contentions, each of which depends on those preceding it:

1. It is possible to develop a series of generic principles to describe the relationships that one spatial component should have with another.
2. These principles lead in turn to coded operatives which serve as logical controls in the simulated evolutionary process.
3. An understanding of how configurations compare in the context of the problem at hand permits the computer to assist the human in recognizing significant discoveries in form, space, and interrelationships. The contention is the computer can gain this understanding.
4. The "significant discovery" identification capability endows the machine with the ability to recognize instances of previously learned concepts.

Unfortunately, the most interesting aspects of the cellular automata work are simultaneously the most difficult to establish and most dangerous to suggest. Nonetheless, the drawings support the contention that we have hit upon a method for modeling such environmental issues as colonization, evolution of community structure, parasitism, and certain processes of immunity and avoidance. It is intriguing to recognize that each of the apparently random spatial configurations is actually carefully ordered through a set of pattern codes and environmental forces.

Perhaps a new aesthetic is emerging wherein our sharpened perceptions will respond to these higher-order patterns which presently seem capable of being highly responsive to needs and resourceful of material.

Notes

(1) Environmental forces might be described as generic rules which assure minimum performance levels for environmental criteria.

(2) The transition function is the mathematical description of the controlling intercellular relationships and is the "genetic code" for shaping all non-mutated structural configurations.

Acknowledgements

The author gratefully acknowledges the assistance of Mrs. Claire Allen and Mr. Geoffry Shannon in preparing this draft. The computing was done on the CDC-KRONOS time sharing system through the courtesy of the Control Data Corporation. The assistance and cooperation of Dr. Alberto Gomez Rivas is gratefully acknowledged. The plotting was done in the time sharing mode using the Hewlett-Packard 7200A at the School of Architecture, Rice University.

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THE HOUSE DESIGN GAME

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Abstract

The house design game is a user oriented operational gaming simulation that: a) involves the family in the design of their house, b) shortens and improves the often inefficient preliminary design stage, c) eliminates misunderstandings from the architect-client conversations and d) informs the client and the architect of the operational consequences of their decisions.

The simulation consists of three sequential games: a) a pre-planning game in which the family, determines their time dependent spatial and functional needs, and selects a desired life style, b) a planning game that determines the size of each room and overall plan in accordance with the information obtained by the first game and c) a house operation game that simulates and evaluates the operation of the house through the mortgage time (1 to 30 years). The modeled house is evaluated according to material behavior, life support system operation, mortgage amortization, communication, and family cohesion.

The game has been tested in the classroom with excellent results. Testing, calibration and evaluation of this model with actual and simulated clients will continue for a one year period prior to public release.

Introduction

The house design game is a simulation developed by the operational gaming and urban analysis studio of the College of Environmental Design. The game was developed during the summer of 1971. The objectives set by the authors when creating this simulation are based on the following needs:

a. The need to involve the user in the design of his/her house.

b. The need to shorten the important but often inefficient preliminary design stage.

c. The need to improve communications between house designer/builder and its user.

d. The need to inform the designer and the user on the consequences of their decisions.

e. The need to bring the services of the environmental designer within the reach of all Americans.

The authors recognize three discrete stages in the process of house-design, a pre-planning stage, a planning stage and an operational stage. Each of these sequential stages was made into an operational game.

The first game in the sequence is the pre-planning simulation and its purpose is to gather initial information about the users. During this game the client(s) and the architect(s) explore the family's time dependent spatial and functional needs, and desired life style. The output of this game is an interacion (bubble) diagram, and a description of the family's spatial needs.

The second simulation, the planning game, takes the output of the pre-planning game and translates it into an operational layout. Each space in the house is independently designed (for ideal size), and in turn all spaces are assembled together on a site, as described by the interaction diagram.

The third and last game is the house operation simulation. This simulation evaluates the operation of the house produced by the planning game through mortgage time, 1 to 30 years. Decisions made by the client and the architect are evaluated and success or failure is achieved through adequate or inadequate fit of the house to the social and economic demands of the family through time.

At all times the gamed sequences can be restarted in light of new knowledge, this is equivalent to an information feed-back process, see flow chart below, figure 1. A detailed description of each game is given below.

So You Want to Build a House
The Housing Pre-Planning Game

To illustrate the ideas during the procedure of initially designing a house, a game has been created which involves the interaction between the prospective house owner (the client) and the architect. The client can be one of many people within a family, now or in the future. This is the role oriented type of game in which the players, act in each of the roles which might affect the design and/or the continuing development of a house.

The basic concept is the design, via "bubble" diagrams, of a house by an architect with the aid of the family for whom the house is being constructed. The rationale is that people are often confused in ascertaining exactly what they

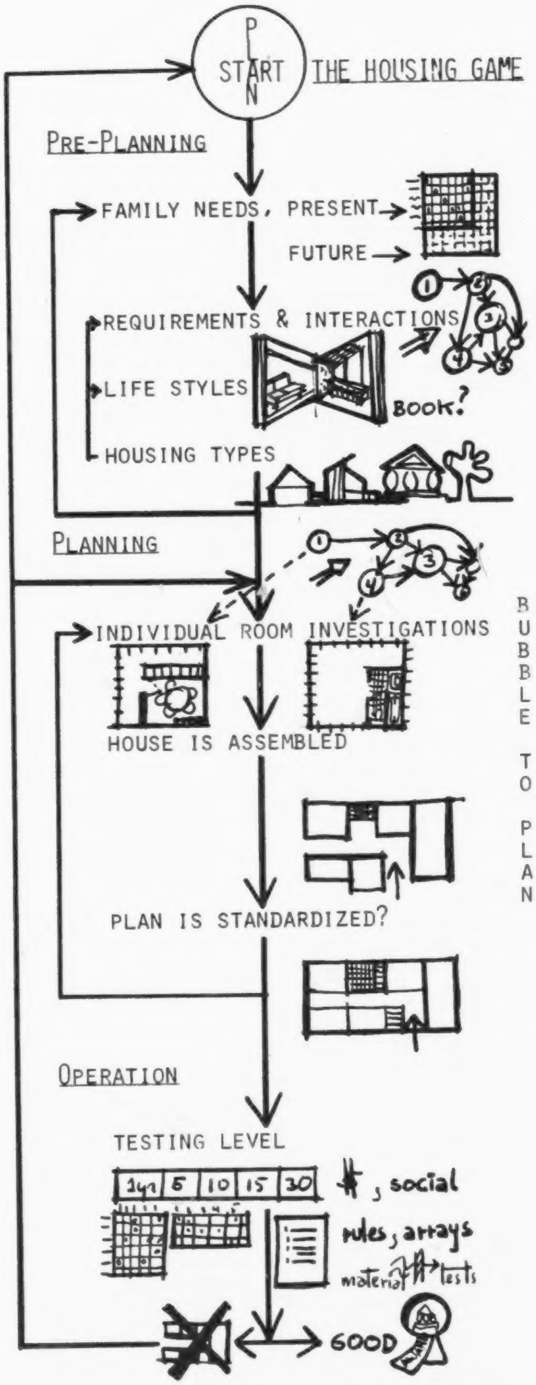
START
PLAN
THE HOUSING GAME
PRE-PLANNING
FAMILY NEEDS, PRESENT
FUTURE
REQUIREMENTS & INTERACTIONS
LIFE STYLES
BOOK?
HOUSING TYPES
PLANNING
INDIVIDUAL ROOM INVESTIGATIONS
HOUSE IS ASSEMBLED
PLAN IS STANDARDIZED?
BUBBLE TO PLAN
OPERATION
TESTING LEVEL
1yr 5 10 15 30
$, social
rules, arrays
material tests
GOOD

Figure 1. Flow diagram for the housing game

want or really need in a house. This game will force them to have a better understanding of their domestic goals and the achievement thereof, or suffer the consequences. Success will be measured by balancing what the family desires in a house, their means of acquiring these wants (finances), and the end result (the completed bubble diagram). Roles will be enacted to emphasize the needs of various members in a family and relating needs to design.

All interaction will be between the members of the family or families and the architect, the latter of which becomes game overall director.

The participants are, the architect (game overall director), the father, the mother, the sons, the daughters with the possibility of various relatives, such as mother-in-laws, uncles, aunts, etc.

The objectives of the player(s) are to achieve his/her goals whether it be in terms of maximizing desired life style, utility, spatiousness, or whatever, in the context of available finances.

The creation of game reality is achieved by giving the architect or game overall director all of the basic elements of a house in three degrees of size (large, medium, small) and three degrees of quality (high, medium, low). Players will be able to assemble their house from the components available. Freedom of choice is only limited by the funds given to a player or family. These funds will be determined by probability, see chart 8, (2), or by the predetermined resources of the client. The concept then revolves around what the family wants at the start of the game in terms of a house, the compromise between what they want and what they can afford, and how close the finished "bubble" diagram matches their original concept.

The steps of play found in the pre-planning house design game are given below:

1. Client fills out the evaluation array, see chart 2.,(3).
2. Determine the economic group of client through the roll of dice, or by client's economic position, and purchase site, see chart 1.
3. Determine the family size through roll of dice, or by client's actual family size.
4. Client purchases rooms, paying game controller:
    a. Client chooses between 3 sizes and 3 finishes for each room (combination of 9, see bubble diagram game

piece).

   b. Client will have a list of rooms available, their sizes and finishes included, see chart 1.

   c. Client will make purchases with available funds.

   d. Client can, at any point during the game, change his or her mind about previous decisions. They will pay out or recover funds accordingly.

5. Game overall director will arrange rooms to client's desires. Utilizing an architect's knowledge, such things as circulation patterns, noise, view and privacy will be considered.

6. Determine total size and cost of house.

7. Assess if final "bubble" diagram fits the needs and desires of client.

So You have a Site
The House Planning Game
The house planning game is in reality the stage in the design of a house where the architect, having gathered all the needed program data, and determined the spatial interactions, proceeds to give form to the interaction diagram. The object of this game is to interest the client in a design and budget that would meet his required needs while the architect tries to compromise his ideas and knowledge with that of his client.

The basic concept is that of translation of the bubble diagram into a layout reality through the use of scaled modular pieces and the use of an existing or gamed site.

Traditionally this design step belongs to the architect or house designer. This game utilizes the client and the architect as the protagonists. It is hoped that the involvement of the client in the actual determination of the final layout will make him aware of the different trade offs between the quasi ideal situation (bubble diagram) and actuality. It is also hoped that the client in consultation with the architect will make the final decision when confronted with the available options (trade offs).

The interaction, participants, and objectives of this game are the same as for the pre-planning game.

The steps of play of the planning game are given below:

1. The architect draws the site or sites on which the house is to be built.

2. The architect draws all site characteristics such as: location of trees, location of utilities and easements, required setbacks, desirable and undesirable views and other pertinent environmental information.

3. Different ordinances such as setbacks density etc. may be appealed now. The result of appeals will be determined according to the ordinance probability array, see chart 9.(2).

4. Each individual space specified by the bubble diagram is now reexamined and reevaluated so as to make desirable effects or furniture arrangements possible.

5. The total bubble diagram is now assembled, circulation and room relationships are formalized and iterated until an acceptable layout is obtained.

6. The total square footage is computed and the pre-planning cost assumption is compared with this new value. If large discrepancies occur, new room sizes and spatial arrangements are made, see chart 10. (2).

7. Based on previous information a list of desired site improvements is made and their cost is computed, i.e. purchase or removal of trees is estimated at $200, chances are taken on soil erosion if trees removed etc., see chart 10.,(2).

Other considerations are left to the discretion of the architect or game over all director. Rewards should be given for sound house placement, i.e. shorter runs on utilities, driveway etc.

So You Bought a House
The House Operation Game
This game simulates and evaluates the operation of the house, designed in the planning game, through time (1 to 30 years). The object of this game is to make the client(s) and the architect or house designer aware of the future consequences of their design decisions.

The concept used in this game is that of decision evaluation through the use of consequence arrays. The arrays represent rewards or penalties and are based on reliability of, life support systems, materials etc.

The protagonists in this game are the family and the architect, although ideally evaluation should be made by a qualified observer.

The interaction, participants and objectives are the same as for the pre-planning game.

The steps of play of the planning game are given below:

1. Owner fills out compatibility array before he goes into pre-planning.
2. Owner gets financing, see chart 3.
3. Owner is given 40% of his yearly income every five years. yearly income x 5 x .4= income for five years
4. Owner purchases insurance, not required.
5. Owner pays bills, taxes, utilities, monthly payments, see charts 11, 12 and 1, (2).
6. Depreciation, see chart 4.
7. Natural Disaster, see chart 6.
8. May build additions at a cost of 1.2 x original cost of similiar room.

Some local spice can be added to this game as demonstrated by the following optional game steps.

9. Owner, does your house still work (compatibility matrix) or do changes have to be made? If they do, you must move into hotel.

   Rates.
   $10 per person per day for room
   $ 5 per person per day for food
   Length of Stay.
      Minor change, five days
      Major change, twenty-five days
      Disaster, twenty days/covered by insurance

10. If house is not suited for human occupancy, there is not a good atmosphere for human compatibility which causes fights to begin. Fights arise monthly until house is again suited for occupancy requirements.

    For each fight, owner spends two days in hotel.

The reader can see that the structure given above is not fixed, but only suggested as a starting point. The architect, school, or house builder using this game should in time develop his own game steps.

A Simulated Round of the Housing Game

Initially the game overall director (architect) explains the purpose, objectives and game pieces of the planning game. The client, informs the architect of his financial resources, in turn the architect gives the client a predetermined sum of money to build his house. The client is shown the game board (cheap green chalkboard) and the desired qualities of the site are noted with different colored chalk symbols, see figure 2.

Figure 2.

The client, is shown the individual color coded spaces, is informed that they come in three sizes and three qualities and is given the room cost array, see chart 1. The architect shows the client a picture catalog that illustrates each of these spaces, (life styles) see figure 3, and asks the client to fill a compatibility array, see chart 2. The client proceeds to purchase his house with the money given to him at the beginning of the game, see figure 2. Game pieces can be rearranged or exchanges for new areas by any member of the family, see figure 3., until the economic resource limitations and family spatial needs are satisfactorily compromised, see figure 4.

Figure 3.

During this balancing process the architect and the client have also recorded the desired spatial and environmental interactions of the house, see figure 4 (different color chalk lines are used to illustrate different interactions desired, i.e. circulation, house, view, green area etc.)

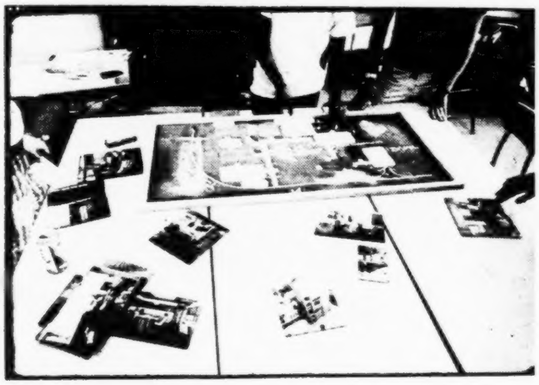

Figure 4.

Whenever agreement about a plan is reached by the game participants (average time 1.5 hr.), The architect and the client proceed to the planning game (a large cheap blue chalkboard) and after deciding on a site, they continue to carefully sketch its properties and boundaries using different colored shalks (roadlines, in white, setbacks in green, utilities in red etc.) see figure 5.

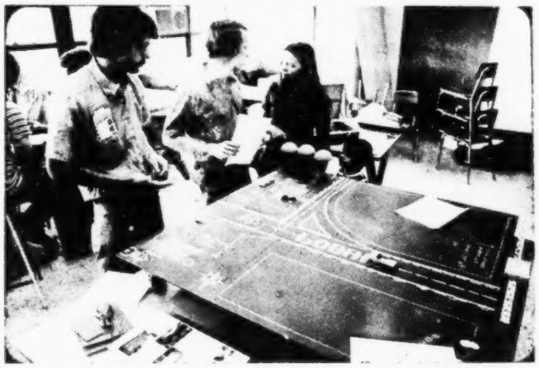

Figure 5.

If the client has no site, a site can be gamed or selected from a catalog. The more refined scaled game pieces are shown and explained to the client by the architect, see figure 6. After an active and tense bargaining and manipulating session, a satisfactory plan is produced see figure 7, (average time 2 hrs.), see figure 7, compared with the interaction diagram of the pre-planning game, see figure 8.

Figure 6.

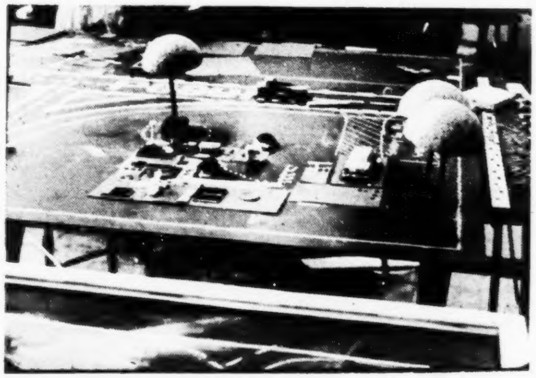

Figure 7.

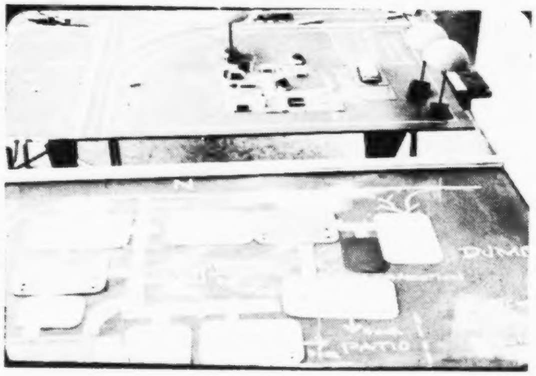

Figure 8.

The architect and the house as designed in the pre-planning games is tested through time as described in the steps of play of the house operation game. A satisfied group of game masters and clients attest to the success of their venture, see figure 9.

Figure 9.

Conclusions and Reccomendations

The house design game is primarily a didactic tool. A tool that demonstrates the many existing constraints in the processes of house design and house ownership. If today's housing determinants are accepted, the house design game effectively guides the client-architect team into the realm of acceptable feasibility. If on the other hand, the users of the house design game, set up to invent a new housing milieu, then the game can be used as an exploratory tool for possible futures. It is in this realm, that of simulating the feasibility, economy and advantage of possible futures, that the authors plan to continue development of the housing game. Other modifications will involve the continuing calibration of the game reality.

The house operation game is presently restricted to a thirty year mortgage period, this restriction will be lifted, and the game will be adapted to play over any mortgage period. The possibility of utilizing different lending rate and the utilization of government financing is being investigated by the authors. An interactive computer-aided accounting system will be added to the game in the near future. The manual version of the game will not be eliminated. The possibility of adding an urban land inventory catalog is also being investigated. This addition would facilitate the process of site selection, and would add realism to the simulation. It is hoped, that a procedure for adapting the game to any region (acclimatizing) will be incorporated into the game.

Some of the reasons for the observed effectiveness of the house design game as a tool that efficiently illustrates (teaches) the realities of housing, more so than the standard methods of illustration such as, booklets, salesmen, lectures, etc., are found in the justifications for operational gaming in general (1), they are:

a. Gaming simulations promote a high degree of involvement.

b. The consequences of one's moves and decisions are immediately observed.

c. Games are self judging, they avoid "authority reactions" in the participants.

d. Gaming simulations alter behavior rather than verbal intentions.

e. The game action is also based on behavior rather than verbal intentions.

f. The synergistic behavior of the parts making the model leads to deeper intuitions about the behavior of the parts than had the parts been studied singly.

g. The game and its rules may evolve with the experience of the players.

The teacher can use the house design game to effectively and rapidly demonstrate the processes involved in house design and house ownership. The structure of the game can be altered to incorporate a series of pre-programmed situations, ie. diverse sites, diverse clients, etc. This allows the student to experience a wide variety of simulated life experiences, something extremely difficult to achieve in the standard classroom of studio experience.

The house-designer can use the house design game for rapid and economic communication with the client. The client, in addition to participating in the actual design of his house, can also find out about the time consequences of building his house.

Needless to say the authors have a strong belief in the house design game as an effective and adaptive tool for the house owner-designer team to use in their quest for adequate shelter.

Notes

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2. Due to space limitations, some charts were not included in this article, they may be obtained from the authors.

3. All charts are found in the appendix to this article.

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Appendix
A selection of some of the most often used charts in the housing game is given below.

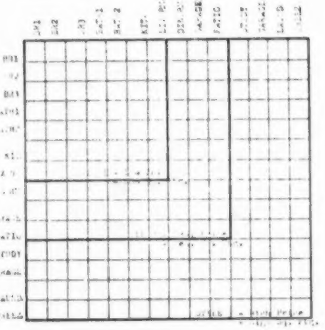
Chart 1. Room Cost Array

Room	Size (Sq. Ft.)		Price - Dollars per Sq. Ft. 18	24	30
Living Room	15x12 20x14 25x17	180 280 400	3240. 5040. 7200.	4320. 6720. 9600.	5400. 8400. 12000.
Dining Room	8x10 10x12 15x12	80 120 180	1440. 2160. 3240.	1920. 2880. 4320.	[illegible] 3600. 5400.
Kitchen	8x9 10x11 14x12	72 110 170	1250. 1600. 2000.	3000. 3500. 3800.	3000. 4000. 5500.
Bedroom	10x10 14x12 19x14	100 170 250	1800. 3060. 4500.	2400. 4080. 6000.	3000. 5100. 7500.
Den (Family Rm)	15x12 20x14 25x17	180 280 400	3240. 5040. 7200.	4320. 6720. 9600.	5400. 8400. 12000.
BATHROOM Full	5x10 7x10½ 10x10	50 75 100	700. 1000. 1300.	900. 1250. 1600.	1200. 1700. 2200.
3/4		40	720.	960.	1200.
1/2		25	370.	600.	750.
Study		100 125 200	1800. 2250. 3600.	2400. 3000. 4800.	3000. 3750. 6000.
Utility		30 60 80	540. 1080. 1440.	720. 1440. 1920.	900. 1800. 2400.
Breakfast Area		80 110 150	1440. 1980. 2700.	1920. 2640. 3600.	2400. 3300. 4500.
CLOSETS Coat		6	108.	144.	180.
Bed Rm		6 8 10	108. 144. 180.	144. 192. 240.	180. 240. 300.
Walk-In		20 30 40	360. 540. 720.	480. 720. 460.	600. 900. 1200.
CLST Storage		8 12 16	144. 216. 288.	192. 288. 384.	240. 360. 480.
Garage	1 Car 2 Car 3 Car			500. 1250. 2000.	
OUTDOOR AREAS Patio				200.	
Court Yard				500.	
Garden				750.	
Swimming Pool				3000.	
Circulation	Percentage @ $18/sq.ft.				
OTHER (Bar, Sewing Rm, etc.)					

* Footage for these rooms will be determined by the player using chart for approx. cost.

** Site purchase : small 50 x 100' $ 2,000.0
med. 80 x 120' $ 3,000.0
lge. 100 x 200' $ 5,000.0

Chart 2. Evaluation Array



EVALUATION

• Directions: Proceeding left to right, fill in the rating you would assign to each room to form relationships. Decisions are to be based on: FUNCTION, CIRCULATION, SITE LINES, NOISE, PERSONAL PREFERENCE, etc.

• Scale: 1 to 10 [illegible] greater associations

• Other Possible Rooms:
Playroom
Bar
Pantry
Dressing Room

Chart 3. Monthly Payment Array (10%)

Amount of Loan	1 Yr	5 YR	10 YR	15 YR	20 YR	25 YR	30 YR
1000	86.99	20.29	12.14	9.56	8.37	7.83	7.34
2000	173.98	40.56	24.77	19.12	16.73	15.44	14.68
3000	260.97	60.83	36.40	28.67	25.10	23.16	22.05
4000	347.96	81.11	48.54	38.24	33.46	30.88	29.36
5000	434.95	101.22	60.67	47.79	41.83	38.60	36.69
6000	512.94	121.66	72.80	57.34	50.32	46.31	44.03
7000	608.92	141.94	84.93	66.90	58.46	54.75	51.37
8000	682.90	162.22	97.07	76.46	66.92	62.56	58.71
9000	782.90	182.49	109.20	86.01	75.28	70.39	66.04
10000	869.82	202.77	121.33	94.57	83.64	77.19	73.39
20000	1799.00	405.53	243.66	191.67	167.27	154.37	146.76

note: all figures not in chart may be obtained by combination.

Chart 4. Depreciation Array

YEARS	5	10	15	20	25	30
type 1	.05	.10	.15	.20	.25	.30
type 2	.08	.16	.24	.32	.35	.48
type 3	.10	.20	.30	.35	.40	.50

Chart 5. Financing Procedure
RULES

A. Cannot borrow more than (2.5)(YEARLY SALARY).

B. No second mortgages.

C. Monthly payments include:
PREMIUM + INSURANCE + INTEREST

D. Depreciation:
PAY = COST OF HOUSE x %....See Chart 4
or
ROLL DIE....See Chart 4

E. Each round = 5 years.

F. Owner may borrow money for expansion or improvements at 10% yearly up to [illegible].

G. Matrix and verbal answer will be used to determine if house meets occupants needs.

H. Changes or additions are [illegible] cheaper if flexibility was built in originally.

I. Flexibility may be purchased at a cost of 10% of original cost of house.

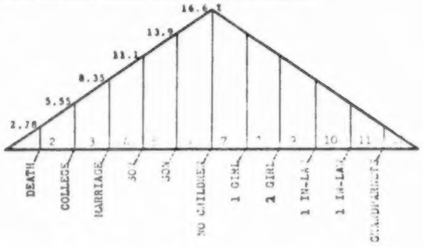
Chart 6. Probability and Cost of Natural Disasters

(Disaster)	(Dice)	(Cost)
1. Termite	2	$4000
2. Tree Falls on House	3	$2500
3. Flooding	5	$ 800
4. Foundation Settlement	2	$5000
5. Wind Damage	6	$1200
6. Small Fire	7	$2000
7. Robbery	10	$ 800
8. Dry Rot	11	$1500

Insurance Against Disasters Purchased Every Five Years

(Disaster)	(Cost)	(Coverage)
1,4,8	$1000	85%
3,6,5	$ 900	75%
7	$500	90%
2	$ 500	100%
Hotel Fees	$ 50	60%

Chart 7. Family Growth Probability Distribution



A DESIGN RESEARCH STRATEGY UTILIZING SIMULATED HEALTH CARE PROCEDURES IN AN ENVIRONMENTAL MOCK-UP UNIT

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Architects facing the challenge of designing facilities for problem areas of a specialized nature or for areas new to their experience face the formidable task of acquiring a sufficient base of information to permit the full utilization of their design capabilities. The architect today would like to identify his role as a comprehensive problem solver and yet works within a fee structure and time schedule more reflective of a less demanding description of his functions. His ability to deal thoroughly with design issues is frustrated by his inability to command the resources of time and manpower to develop the necessary information base needed for a penetrating design analysis. On normal time pressures, he can penetrate the problem to the extent of becoming familiar with some of the basic literature, perhaps visit comparable facilities and in addition to whatever can be supplied by the owner group, make do with this level of preparation. The same pattern of involvement is repeated over and over in various communities with little possibility for any designer to make a significantly greater depth of penetration into the problem except through specialization. The architect so prepared is not in a strong position to raise, in the programming phase, the penetrating questions which direct the users to more thoroughly question their premises and demand a significant improvement in the performance expected, nor can he serve as well the function of providing preliminary design and cost implication of various alternative operating policies which are valuable, essential elements of the programming dialogue.

The hospital user group faces similar problems in having limited resources to investigate the field in depth and to be more knowing in describing their problem in a way that has the highest potential for matching needs and capabilities.

Typically, a facility planning committee in the hospital or any other institution while professionally competent will usually have had no previous experience in programming building facilities and when the problem involves new and unfamiliar special facilities may have had no experiences in either the design or use of such spaces. The likelihood of significant design improvement emerging from this situation is obviously not hopeful.

The project described in this paper while set up to meet the specific needs of coronary care units is seen and presented as a possible model approach to a needed area of applied design research. This type of research is described as situational rather than general. It is both pragmatic and eclectic, utilizing whatever approaches that may be necessary to yield the information required.

To illustrate the range of research tools utilized in the study, the matrix shown in Figure 1 depicts the major decision areas in the CCU planning and design process against the various techniques available for developing contributing information in these areas. This is included to indicate that while this presentation deals more specifically with the problems and impact of environmental mock ups, that it is only one of many devices used and that it's use was related to insights gained through various other techniques.

The researchers were concerned that the studies and results should be complete and authoritative yet not become an inhibiting factor for continuing innovation by establishing overly doctrinaire and absolute recommendations. Nevertheless, many small hospitals with limited ability to explore the problem area require unambiguous models to aid their decision process. The strategy was to make specific recommendations whenever supporting evidence was available, and to present

● **MAJOR IMPACT**

○ **MINOR IMPACT**

RESEARCH TECHNIQUES	**DECISION AREAS**								
	determination of need	alternative care strategies	policies and procedures	unit capacity	unit location	unit configuration	room size	equipment layout	room amenities
total system model analysis	○	●	○		○				
generic nursing station type study				○	●	●	●	○	
generic CCU type study		○	○	○	●	●	●	○	
literature search	○	●	●	○	●	●	○	○	●
patient questionnaire		○	○			●	○	○	●
medical staff questionnaire	○	●	●	●	●	●	○	●	●
activity analysis			●		○	●	○	●	
computer simulation of patient flow	●	●	○	●					
mini-max storage analysis			●		○	○	○	●	
CCU observation study			○		○	○	●	●	○
simulation of emergencies in mock-up			○			●	●	●	
ergonomic studies using mock-up			○			●	●	●	
expert consultation	○	●	●	○	●	●	○	●	●

Figure 1.

issues clearly when significant differences in supporting evidence existed, but in any event to relate all design recommendations to care strategies and procedures and to document thoroughly all data involved in making design decisions. In this way various users will be able to extract data ranging from a most basic level to that of complete design description.

As a design oriented project it stops short of undertaking basic research into man environmental relations. The approach defines a middle ground between what each designer-owner group can develop in isolation and the laborious and meticulous scientific research ultimately needed as a basis for design.

While it is felt that the coronary care unit represents an excellent vehicle for developing an approach to this research strategy, entry into the field of coronary care was simply fortuitous.

In the spring of 1970, Colin Clipson, a designer interested and experienced in systems and ergonomic studies and the author were approached by a team of physicians, nurses and hospital administrators to consult with them on their efforts to improve the capability of Michigan hospitals in providing a high level of care for patients suffering heart attacks.

The project's charge is to aid Michigan hospitals establish and improve their capabilities in providing coronary care through nurse and physician training and advice and financial assistance is setting up units. The project staff after a year of operation perceived a problem in that unit design and layout have presented serious obstacles to proper performance of the clinical procedures and psychologically supportive environment for the patient. While both principals had some previous experience in the hospital field, they were essentially uninformed in the area of intensive care for cardiac patients. After a briefing by project physicians, visits to local CCU's and a review of the classic literature, a three month summer involvement was undertaken to both offer architectural consultation with project hospitals and to develop a research plan to bring to bear specialized design insights in the development of next generation coronary care units.

From the outset the design research team viewed the CCU project as an excellent vehicle for establishing a model for the study and presentation of design oriented data for specialized facilities of all kinds, though acceptance of our proposal was based strictly on the anticipated benefit to be derived in the coronary care area generally and on the design of the intensive coronary care areas specifically. While it is not, for the purpose of this paper, necessary to expand on the specifics of coronary care units, some general familiarization is important.

The concept of caring for coronary patients in a specialized intensive care area dates back only to the early 60's. The clinical basis for the CCU rests on the discovery that externally applied electrical shock can restore effective pumping to a heart developing potentially fatal arrhythmia. This along with the ability to temporarily maintain blood flow in an arrested heart by rhythmic compression of the sternum made recusitative effort feasible and practical.

Development of electronic monitoring of cardiac rhythm and other physiological parameters with audio and visual alarms when conditions exceed present limits, set the stage for the development of the CCU.

Intensive coronary care has been described as a system of specialized care for preventing death from complications of acute myocardial infarction (heart attack). It requires the delegation of authority to specially trained nurses to diagnose and treat specified complications. Nurses are available 24 hours a day and care for 2-3 patients per nurse assuring a high level of personal care. Ideally the physician care is centralized in the unit director as a means of assuring prompt unambiguous application of the best care procedures available.

The CCU is the setting in which predetermined policies, trained personnel, electronic monitoring, emergency equipment and supplies are all immediately available for instant response to life threatening emergencies.

In recent years the emphasis in the CCU has shifted from resuscitative to preventative efforts. The complications that cause sudden death provide premonitory signs sufficiently early to permit preventative measures and consequently the preventative management of the coronary patient has significantly reduced the number of emergencies in the unit.

The early experience with the CCU's demonstrated that the hospital death from myocardial infarction could be reduced by approximately 33%. This same level of success is being achieved by most hospitals with Coronary Care Units and serves as a stimulus for all but the smallest hospitals to provide this type of specialized care. Since the early 60's probably 3000-4000 hospitals have established units and pressure exists to install units in the remainder as well as to expand and improve existing units.

The role of environmental mock up and simulation can best be introduced by listing a number of distinct purposes to be served by this study technique.

Purpose

1. To familiarize the design research team with emergency procedures utilized in coronary care.
2. To aid in evaluation, of existing space standards as promulgated by various agencies.
3. To provide the setting for obtaining photographic records of emergency procedures and making them available through publication to other designers.
4. To function as a catalyst in eliciting expert opinion on CCU procedures and design.
5. To enable researchers to investigate optimum locations for fixed and moveable equipment items and to document recommendations.
6. To test new configurations under simulated conditions and obtain expert evaluation.
7. To obtain a spectrum of controlled photographs to be used in assessing psychological responses to varied clinical settings
8. To serve as an aid in coronary care nursing education.

Mock Up Description

The structure is comprised of a set of easily erected, easily changed wall panels, storage units, and life support equipment, which can be set up in a wide variety of ways, to realistically provide an operational and physical environment for cardiac care. The mock up unit carries a complete range of room furnishings, so that the resulting configuration is both operationally and visually very realistic.

The unit was fabricated by the researchers in the department wood shop using 1" x 4" pine frames with 4' x 8' homosote face panels painted a typical hospital yellow-tan. Using simple drilling jigs and assembly jigs, 17 wall panels, service panels for electrical supply, oxygen, air and suction, fabrication of bracing members, shelving and painting, etc. were all completed in less than seven man/days.

Materials in the unit ammounted to $320.00.

Five of the seventeen wall panels were built with removeable window areas and could be readily moved into any position as well as quickly replaced by a solid panel. Frames were pre drilled to permit edge to edge bolting in three places. A 1 x 4 carrying a K.V. track is sandwiched between each panel frame to permit adjustable height shelving wherever required.

The initial installation of the unit was in a carpeted classroom in the Towsley Center for Post Graduate Medicine. The structure had to be free standing, and for this reason, was stabiized with 2 x 6 beams at each module with external diagonal bracing. The overhead 2 x 6 beams were utilized for hanging T.V. lights and cameras. A crew of four men completely erected and furnished the unit in less than two hours.

This data is included to indicate that the mock up does not require a major committment of time and materials, and can be considered as a study device on relatively low budget projects.

Simulation procedures

A series of cardiac conditions are simulated by the utilization of Resusci Anne, a life like "robot" patient which can be electronically programmed to develop a range of arrythmias and life threatening states, e.g., ventricular tachycardia, ventricular fibrilation, cardiac arrest. Changes in the ECG output of the "patient" are displayed on cardiac monitoring equipment, in and around the unit. The patient is also equipped with a special thorax skin so that cardiopulmonary resuscitation can be performed. Three member teams of nurses watch the progress of the patient on monitors which are both at the patient bedside and at the nursing station adjacent to the patient bed area. The nurses are provided with the patient's case notes, so that as each simulation period starts, the nurses can familiarize themselves with the patient's condition, much like at a change of shift.

Each group of three participants operated in the unit over a 40 minute period responding to three distinct sets of problem events. The course of the three events was determined within an overall framework by the training nurse in control who could program normal and arrythmical ECG traces via Resusci Anne on the monitor. This nurse, at a control desk responded by voice for the patient, answering nurses questions and raising typical complaints and concerns. The nurse in control adjusts the "patient's" response to treatment interventions both electronically and verbally while the second training nurse kept a check list with notes for a subsequent critique.

After each 40 minute session the configurations were changed and the design researchers and training nurses and participant nurses discussed problems of clinical procedure, design variables and suggested alternatives. In earlier sessions critiques of the simulation itself led to subsequent changes.

A layout of the simulation area is shown in Figure 2.

Video Recording

Recording of the activities in the mock up is achieved by the use of two T.V. cameras. One camera is located over the unit, providing an elevated view down into the mock up. A second camera is situated outside the walls of the unit, and provides eye level views through openings in the sides of the mock up. Both cameras are controlled and synchronized from a central T.V. control panel adjacent to the mock up. Simultaneously, the visual output is displayed on T.V. screens for the benefit of the instructors, observers, and other classes outside the mock up area. "Instant replay" can be used for discussion and critique seminars after the training seminar is completed.

A thirty-five minute video tape has been prepared for general educational purposes.

Summary of experiences

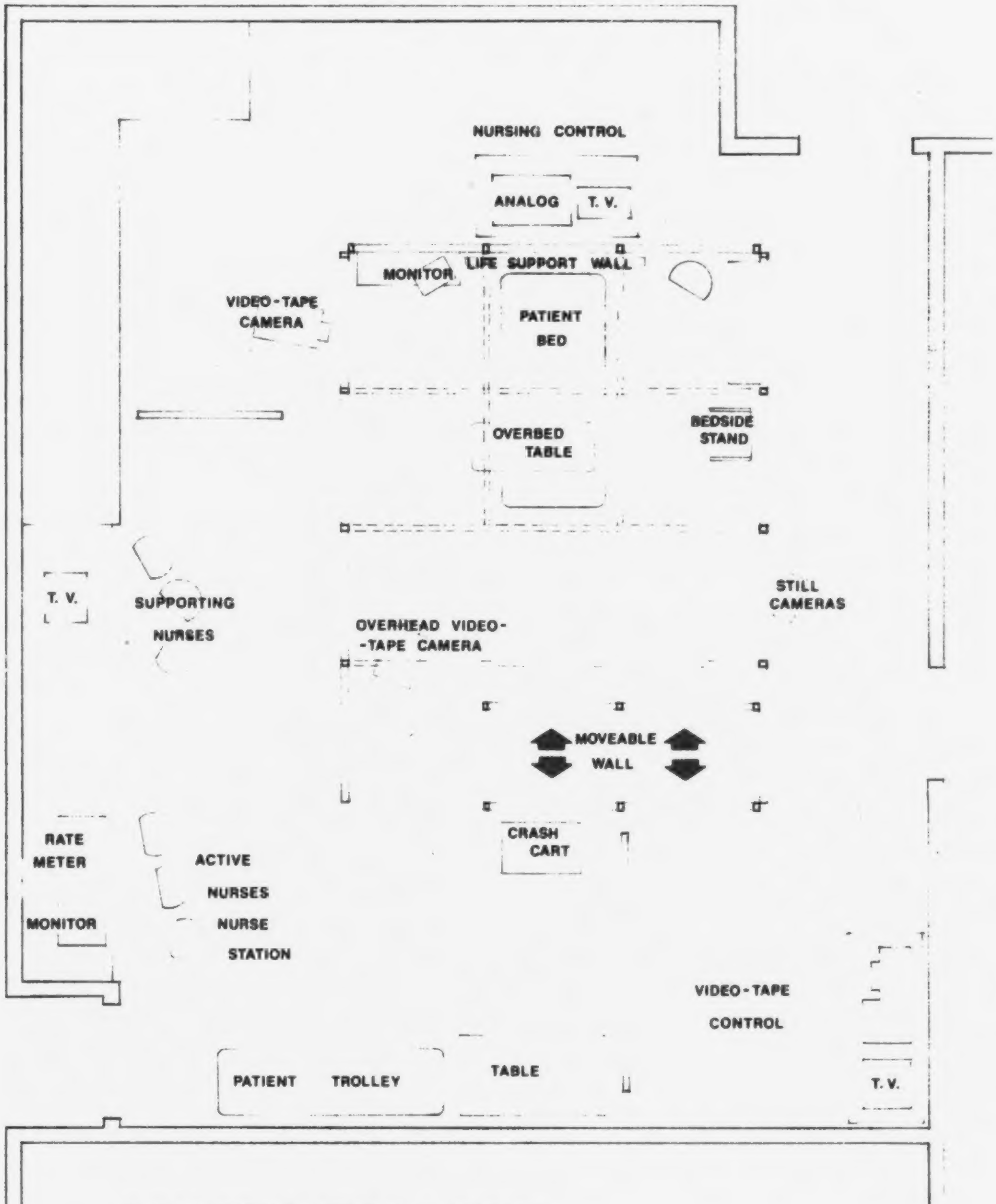
This section will expand upon the purposes established for the unit, and discuss results achieved.

1. To familiarize the design research team with emergency procedures utilized in coronary care.

Perhaps the major reason leading to the use of the environmental mock-up unit was the difficulty of obtaining first hand experience with the events involved in emergency treatment of patients. Though the various members of the research team spent many hours in many hospitals, it was nearly a year before an emergency was observed by a member of the design research Team.

The design team documented from the literature and through consultation, the sequence of procedures, number, and role of participants and yet lacked an operational grasp of the emotional and spatial dynamics of the situation. A cardiac emergency is the ultimate medical emergency. The patient is literally resuscitated from a condition only problematically distinguishable from final death. The resuscitative activity is at a high level with the area crowded with 5 to 7 direct participants, and even more peripherally involved or redundant medical personnel.

Even given the possibility of observing without interference, the architect desirous of witnessing an actual emergency must be prepared to


NURSING CONTROL
ANALOG
T. V.
MONITOR
LIFE SUPPORT WALL
VIDEO-TAPE CAMERA
PATIENT BED
OVERBED TABLE
BEDSIDE STAND
T. V.
SUPPORTING NURSES
STILL CAMERAS
OVERHEAD VIDEO--TAPE CAMERA
MOVEABLE WALL
CRASH CART
RATE METER
ACTIVE NURSES
MONITOR
NURSE STATION
VIDEO-TAPE CONTROL
PATIENT TROLLEY
TABLE
T. V.

C.C.U. SIMULATION LAYOUT

Figure 2.

spend many hours in the unit awaiting the event for which massive efforts are being expended to prevent. Currently, in well managed units of moderage size emergency procedures are becoming more and more rare, often only 2-3 per month.

The possibility of installing CCTV in an actual patient room was considered and ultimately rejected as an intrusion into both patient and staff privacy at so critical a time. In addition, there was no way of determining how situation dependent these observations may have been. Thus the decision was made to use a changeable, realistic mock-up, wherein the procedures could be studied under controlled and varied conditions.

Results

There was little doubt that the use of the unit fulfilled the objective. Subsequent experience with witnessing actual procedures convincingly demonstrated that the simulation presented a good fascimile of actual events. The crowding around the patient, the physical effort required, the need for coordination, as well as individual effort were made extremely clear as one watched the events develop.

One's perception undergoes a considerable change when he goes from a situation in which he knows that a patient's chest will be rhythmically massaged to when he experiences a nurse climbing onto the bed and utilizing her whole efforts to load and unload the sternum with a stiff and rocking motion. Seeing half a dozen physicians and nurses straining to read monitors, hurrying by people and equipment, stepping over and reaching over electrical cords, tubing and electrodes, hearing orders, comments, and requests, deliver a good approximation of the action.

While excellent as straight reportage of what occurs, and even though participants were serious and trying to perform effectively, one cannot simulate the emotional climate that exists when a life is in the balance. Knowing this, the researchers felt that potentially disruptive events would be more serious in actual practice. The element of mess was also missing In heart stoppage, patients may vomit or void themselves thus adding additional trauma in the form of stench and waste in and around the patient's bed. These are certainly drawbacks but have been accounted for by extrapolating beyond that which could be observed.

2. To aid in evaluation of existing space standards as promulgated by various agencies.

As the clinical experience of the pioneer CCU's were published, first generation units were built following the examples of the pioneer units. Upon entry into the problem area, many of the characteristics which identify the CCU were contained in a variety of available guides and standards. Typically, these standards would specify the services oxygen, air, suction, electrical outlets, etc., recommended room dimensions, and safety precautions. Analysis indicated that most hospitals were unable to meet the full recommendations and that lacking insight into the relationships between operation and facility, the architect and to a lesser degree, the hospital staff, were unable to satisfactorily adapt in less than ideal circumstances. Beyond this, more refined determination of equipment and services was beyond the designer without a major effort to immerse himself in understanding the critical events involved in treating cardiac patients. The goal was to produce a comprehensive set of design recommendations based on the latest cardiac care procedures.

Results

Experience with the unit suggested that firm recommendations regarding overall size and clearance could be overly simplistic. Initial configurations, set up to provide the generally recommended room sizes, indicated they were workable and probably even desirable. From experience in hospitals one could also see that many rooms were, because of existing conditions, not nearly as spacious and yet supported these activities. Work with the unit indicated that working space could be reduced below generally recommended levels and resuscitative activities could still be carried on. The larger rooms were simply more forgiving of placement of emergency items, and could tolerate the presence of furniture and other items of a temporary nature that might be in the room at the time of the emergency.

It was found that smaller rooms could work effectively when, by preplanning, staff would agree on locating moveable equipment in designated area and to clearly allocate roles, and limit the number of staff involved.

Similarly, trade-off between space and built-in equipment could make smaller rooms satisfactory. Beyond this we were able to show that emergency situations were better handled with fewer participants than normally present.

We concluded that the larger rooms were good practice not necessarily for the present, but in anticipation of new equipment and procedures that might begin to reduce the mortality from circulatory failure which, at present, CCU's are essentially no better at preventing than are regular medical areas.

Conclusions in this area are subject to the same potential critiques observed under the first objective, i.e. under truly emergency conditions, behaviour, and therefore space needs, might vary from observations made under less stressful circumstances.

3. To provide the setting for obtaining photographic records of emergency procedures and making them available through publication to other designers.

Beyond running the experiment for the benefit of the research team, we faced the problem of developing an equivalent familiarity with process and facility for the users of published information. High priority was given to recording the event through both Videotaping and still photography; and subsequent sequence photography from the taped footage. In the first simulation, the photographic record had the advantage of spontaneity while lacking in the most descriptive camera angles largely as a result of the space in which the unit was constructed.

The present location provides an improved set-up for obtaining more useful photographs. In addition previous experience will aid in reproducing situations most likely to identify critical events as they relate to facility design.

Results

We have over 3 hours of Videotape which have been reviewed for relevancy to physical design and layout. An edited 30 minute segment is available for interested designers as well as for nurse training purposes.

Thirty-five mm. sequences have been shot from the footage to document specific space standards. Additional situations are now being set up and photographed directly in the newest version of the mock up unit which utilizes the most modern equipment donated by manufacturers for the purpose. First generation photographs while unsuitable for publication have demonstrated their potential usefulness.

4. To function as a catalyst in eliciting expert opinion on CCU procedures and design.

This objective is admittedly after the fact. It was found that, prior to experience with the unit, attempts at deriving design related information from nurses and physicians was less than satisfactory. Experts when communicating with architects tended to filter their experiences and tell only what they thought the architect wanted to know. A pleasant unanticipated benefit of the mock-up unit was its effect on structuring a higher level of pertinent communication between physicians, nurses and the research team.

Following each 40 minute simulation, researchers met with the participants in a brief review session. These discussions yielded not only critiques of the CCU room layouts but served as a springboard for comments and insights across a wide range of CCU policies, procedures and design.

Results

Follow-up sessions produced a large number of valuable anecdotal experiences in CCU, suggestions and insights and contradictions which led to the formulation of a questionaire which was run as a pilot on a nurse training group of experienced CCU nurses and subsequently on an expanded list of trained nurses.

5. To enable researchers to investigate optimum locations for fixed and moveable equipment items and to document recommendations.

In an environment where seconds saved in procedures requiring coordinated efforts of a number of trained specialists each of whom have specific, tasks involving fixed and moveable equipment, the optimum location of people and machines has dramatic and serious consequences. Experience with CCU's in many hospitals has shown considerable variation in placement of key equipment items and some evidence that people learn to "make do" with some horrendous situations. Existing hospital rooms permit an analysis of a given configuration but mitigate against controlled manipulations and detailed study of alternative positions. The variable mock-up allows the researcher to personally take on the role of participant as well as to observe and study actual participants as they perform specified tasks under varying situations.

Results

These studies have not as yet been made, although pilot studies utilizing some of the largest equipment items has been done. No difficulty is foreseen in performing the studies and documenting results

6. To test new configurations under simulated conditions and obtain expert evaluation.

The sum of all investigatory techniques will begin to indicate possible departures from current practices. To whatever extent this becomes true, whether in terms of basic layout or in more detailed aspects of the design, it is intended that these potential recommended practices be subject to experimental use by medical teams to assess their effectiveness.

Basic relationships of bed position, room openings, clearances and toiletting provisions, fixed and movable equipment will be varied and used under controlled conditions. In some instances physiological stress may be measured as an indicator, in others patient and staff preferences will be sought and analyzed. Medical personnel will operate the facility as well as the research staff in order to provide comprehensive evaluation of potentially innovative configurations.

Michigan hospitals planning new units may set up alternative configurations for evaluation by project staff and hospital staff as an aid in reaching design decisions.

7. To obtain a spectrum of controlled photographs to be used in assessing psychological responses to varied clinical settings.

The range of experimental data relative to the impact of the CC room on the psychological state of the patient is extremely limited. On the other hand it is clear that patients requiring the facility are in a state that makes their electrical stability extremely sensitive to various emotional factors. An assessment of the specific environment experienced by a patient is made difficult because the level of care in CCU's involving usually one nurse to not more than three and often two patients that this personal attention overides any focussing on specific disatisfaction with environmental factors.

By identifying features of the patient area environment that may be more or less stress producing, it is intended that comparative photos be made as a basis for determining preference on the part of healthy people in general as well as former patients.

8. To serve as an aid in coronary care nursing education.

The interdisciplinary make up of the project team facilitated easy cooperation in meeting nurse training as well as design needs in the use of simulation. Nurse participants, many of whom had CCU experience were able to gain experience in operating under standing orders different than in force at their own hospitals. In addition, they could participate in various roles as another means of broadening their experience.

A major advantage relative to the training function was the ability to observe one's own performance immediately after the event through the medium of Video tape. Combined with group critiques, nurses not only could see their actions but also discuss alternative actions which may have been more widely used by other participating nurses.

Results

To date approximately thirty nurses have participated in training sessions as an applied portion of their specialized training. Directors of the nurse training program express enthusiasm for it's value in clinical training and have considered taking the unit to out state locations for additional sessions. Though limitations of budget ruled this out, the 30 minute Video tape edited from the first training effort is being so used in current training sessions around the State of Michigan.

Request for opportunities to use the facility have been received from the Inservice Education Div. of the University Hospital and another from the University Hospital's CCU. It is planned to mock up versions of their new unit as a means of breaking in new nurses assigned to the unit.

A peripheral benefit of the collaboration has been achieved in that the nurses exposure to the project architects has tended to increase their concern with problems of layout and design. It is likely that nurses so exposed will be better able to get the most from their own unit layouts as well as to be better participants in future unit planning activities.

Summary

In summary, we have described an overall eclectric approach to providing procedural and environmental design information for a specific specialized facility. For reasons which may to some extent be unique to our study area the use of an environmental mock up unit together with use simulation has provided and promises to further provide important contributations to both our understanding of and ability to communicate findings related to Coronary Care to hospital officials and architects facing the design of these facilities. Value of the technique relative to effort expanded was considered to be excellant. Since our efforts with environmental simmulations revolved exclusively around our immediate needs we can only speculate on it's value in other applications.

When some of the following conditions exist the use of environmental mock up might be considered.

1. When design information gained can be applied to large numbers of units under design.
2. When subject area is difficult to study and manipulate in situ.
3. When the man-machine-environment is observably responsive to changes in its parameters.
4. When effects can be observed and studied over a limited time span.
5. When motivation of participants is sufficient to ensure proper response.
6. When the critical elements of the environment can be properly controlled.

The project described is now approximately 60% completed. Those associated with it are optimistic that it represents an important area in the overall spectrum of environmental design oriented research. Major effort now is focussed on communicating information developed in the course of the project into a format sufficiently flexible to serve a wide range of needs without being either overly prescriptive nor open ended to the point of vagueness. If successful, the work should serve to raise the level of design of Coronary Care facilities by eliminating the informational impediments that limit the creative interactions between well informed designer and user.

Beyond the immediate application is seen the possibility of similar process oriented design investigations attacking problem areas in all fields. As this time approaches further efforts should be expended in improving storage and access to this material as well as to assure regular updating of stored information.

RESIDE: A Gaming Method for Improving Environmental Interaction

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The American Institute of Architects

This study examines changes in self-concept, or feelings about oneself, on the part of environmental occupants, or users, who were involved in the design decision-making process of their environment. The study focuses on the degree to which users believe they can influence their own personal environment, which is herein referred to as the potency aspects of self concept. It also includes their liking and sense of activity or involvement with their environment, as well as the effect of increased involvement by non-designer users on design quality. Involvement of users was proposed to have been increased by means of a residence design game, RESIDE. The independent variable, then, was game or non-game techniques of house design. The dependent variables were the user's sense of potency, quality of design on an individual basis, and quality of design on a group basis.

Purpose

The purpose of the study was to develop methods by which a typical residential dweller could improve his ability to manipulate his own environment in order to suit his personal and changing needs. The study examined two areas in the search for such a method. First was the automated fabrication of physical components which could be mechanically assembled, disassembled and reassembled with minimal skill prerequisites. The second area consisted of game rules that structured interpersonal communication among users (thereby facilitating trade-offs) and game components that provided for the evolution of a residential design. Prior to designing the details of the physical component system, the game was developed and tested to insure achievement of the "human" (psychological) goals, i.e., increase of user sense of potency without loss of design quality.

Importance of the Study

In seeking the most suitable or most satisfactory living conditions, dwellers presently select from a locally available range of financable options, perform nominal adjustments (such as coloring of surfaces, planting of shrubs, etc.) and then adapt their living styles to use the dwelling to best advantage. The already existing house, due to its physical inflexibility, seems to dominate the more more adaptable dweller; the major decisions which determine environmental quality have been made long before the occupant is known.

The problem may be understood by examining the existing development process in which the key activists may be seen as the money lenders (who set design criteria that appear to be as universally acceptable as possible), land speculators and home builders (whose interests are optimization of immediate profit).[1] The following two analogies may help clarify the effect that the interests of these activists have on the environment. Eating establishments that strive for "universally accepted" tastes, tend to produce bland food. Even seasoning by the consumer fails to bring the food to levels of excellence. Similarly, great efforts toward universally acceptable home sites lead to bland, near-uniformity of front, rear and side yards, and of size and shape of sites. In nature, migrating birds have short-term investments in any given locale; accordingly, they build nests that are quickly fabricated but also deteriorate shortly after the birds leave. Similarly, land developers and home builders seeking immediate profits opt for low initial construction costs rather than seeking low continuing maintenance costs. Thus, we might expect bland residential environments with high maintenance costs that are ideally suited to the needs of money lenders, land speculators and home builders, but not necessarily dwellers.

A problem created by "someone else" is often left to be solved by "someone else." The pride associated with personal effort cannot be expected when such effort has not occurred. The problem of user passivity, or impotency in the development process, may be seen to encourage poorly maintained environments (littered, eroded and shambled, but tax deductible), desensitization between users and their environments (towards a mutually self-destructing pollution), and a sense of frustration and helplessness about correcting it (because the government or "some expert" will). In extreme cases of frustration, mass demonstrations and environmental destruction have occured. (Sit-ins, fires and demolition have caused the government and "some experts" to take notice.)

A second problem of user satisfaction with the built environment stems from environments that remain relatively static or unchangeable. Present environments undergo great change at the time new facilities are constructed. The residential user appears most compatible with an environment immediately after selection of the dwelling unit and during the early stages of occupancy, then diminishes as family needs and preferences change without an equal measure of corresponding change in the environment.[2] An example of this phenomenon is the fact that most buildings are torn down due to their inability to respond to current user needs rather than due to structural deterioration.[3] As with incompatible acquaintances, users may find environments incompatible. They may accordingly avoid or neglect them or treat them with hostility or abuse. The consequences on the problem of user passivity or the problem of static unresponsive environments may be impersonal neglect, incompatibility, and environmental destruction.

Hypotheses

The first hypothesis evolved from the observed correlation between satisfaction and involvement, the personal pride and sense of excellence that comes with a "job well done." The potency aspect of self-concept also appears correlated to satisfaction and involvement; in instances of high personal involvement and high satisfaction, the person involved was, by definition, a potent ingredient in the process. Using gaming as a method for increasing involvement and hence potency,
1. Users that designed their homes using gaming were hypothesized to have a stronger resulting sense of potency than users whose homes were designed by non-game techniques.

The second hypothesis grew out of traditional designer concerns for æsthetic outcome, inasmuch as the role of designer shifted from one of traditional total design execution to that of design facilitator ... the moderator of the game. Because the skill of the designer was still present, although acting in an advisory role in which the clients became the actual design decision makers,
2. Houses designed by gaming were hypothisized to be no better or worse æsthetically than those designed by traditional non-game techniques (i.e., design evaluations would not differentiate the groups).

The final hypothesis also related to æsthetics, but was concerned with the houses in groups (such as would occur in development groups) rather than on an individual basis. Because the clients who use the game had a greater role in the design process and because clients do not share the design education common to the designers, their expressions were anticipated to be more diverse. This diversity should probably cause greater interest on a group basis, so that,
3. Houses designed by gaming were hypothisized to be more pleasing, æsthetically, as a group than the group of houses designed by traditional non-game techniques.

Research Design

Fourteen students in a design methods seminar at the School of Design, North Carolina State University, were each asked to design five houses. The students were all asked to find their own clients and to find a variety of family situations (i.e., some bachelors, some childless couples, some small and some large families, etc.). The students' experience ranged from third year enrollment to the graduate program. Most of the students were studying architecture, some landscape architecture and some urban design.

The pre-treatment situation involved dividing the student designers into two groups, those who would use the gaming method and those who would use traditionally taught design methods. The division was accomplished by dividing the class into two seminar-size groups. Because choices were made according to meeting time convenience, design skills were assumed to be randomly distributed between the two groups. (Observation of student backgrounds in each group tended to confirm the assumption.) The first group was shown a site that was pre-established on the game board; they were instructed in the playing and monitoring of the game. Each designer of the second group was given five site plan sheets of the same site as that on the game board. Only room arrangements were shown. The first group was to merely leave the game board as it was when they and their client were done with a house design. (Research Assistants recorded the designs and reset the game board.)

The treatment consisted of the actual house designs. Gaming clients were brought to the "game room" at the school; non-gaming clients could meet with their designers when and where they desired. The treatment period was five weeks long beginning and ending at the same time for both groups.

The post-testing consisted of (1) a questionnaire sent to the clients to determine potency feelings, (2) a sorting of the design into five categories (very poor, poor, fair, good, and very good) by ten design professionals (practitioners and university faculty), and (3) a selection of one of the two design groups as "most pleasing" by ten other design professionals. The designs submitted by the students were number-coded, they were all rendered in the same way by one research assistant and all were photographed by another assistant. The design quality sorting was done from the photographs after shuffling. The group design quality test was accomplished by decoding the designs and mounting the game and non-game groups onto two display panels, "A" and "B."

Findings

1. A factor analysis was performed on the client replies to the questionnaires. Most of the questions used a semantic differential format. Two of the questions, designed to be self-checking, were specifically intended to determine levels of potency feelings. The results were:

	Number	Mean	Standard Deviation
Non-game clients	42	13.0	3.1
Game clients	18	14.7	2.4

   Potency feelings of game clients were higher, as hypothesized. Using the t-test, the difference was found to be significant at the .05 level of significance.

2. An analysis of variance was performed on the quality ratings and on the house designs. The total sum of squares was partitioned as follows: Groups (G), Houses within Groups (H(G)), Raters (R), Interaction between raters and groups (R * G), and the Interaction between Raters and Houses within Groups (R * H(G)). The mean rating for gamed designs was 2.54 and for non-gamed 2.38 (i.e., the gamed were slightly favored.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
G	1	3.57	3.57
H(G)(1)	62	189.81	3.06
R	9	73.98	8.22
R * G	9	25.16	2.80
R * H(G)(2)	558	510.46	.91
Total (corrected)	639	802.98	

   The following statistics were computed and approximate F-tests performed:

$$\frac{\text{G Mean Square}}{\text{H(G) Mean Square}} = 1.166 \text{ (not significant)}$$

$$\frac{\text{R Mean Square}}{\text{R * H(G) Mean Square}} = 8.98 \text{ (significant at .01 level)}$$

$$\frac{\text{R * G Mean Square}}{\text{R * H(G) Mean Square}} = 3.06 \text{ (significant at .01 level)}$$

   Although the ratings between gamed and non-gamed designs indicated that the gamed houses were more æsthetically desirable, the difference was not statistically significant. (Note -- many raters appeared to strongly favor one group or another even though neither they nore the assistant conducting the test knew which house belonged in which group.)

3. Seven of the ten raters said that the gamed houses, as a group, were more interesting.

All three hypotheses were supported. The only reservation was in the number (1) of responses to the two groups; the number of responses should have been much higher in order to secure statistical significance.

Implications of this Study

The one most fundamental implication of the supported hypotheses was the verification of the potential value of the gaming technique and a simple, reassembleable component construction system. Projecting the implementation of this scheme, users could own an inventory of components (as children own Lincoln Logs, erector sets, or model train components) rather than "a house." They could periodically re-game their environments and reassemble their components. Personal environments could change over time in response to changes in user needs or life style, site or locale changes or to any other changing circumstances. Housing could become much like dressing, in that users own components (various shirts, socks, trousers, coats, etc.) that are reassembled periodically (for clothing daily or less -- for housing weekly, monthly, annually, etc.) to suit the condition of the time (mood, climate, life style, etc.). Users could be as intimately involved with their total environments as they are with dressing. And care and grooming might replace neglect and pollution.

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(1) used as "error" term for groups

(2) used as "error term for Raters and R * G

NOTES

(1) One excellent document describing the development process and the perceptions and needs of roles within that process is Project Finance and Loan Development, by Dr. Carl Tschappat and Mr. Paul Farrell (Coral Cables, Florida: Florida Association of The American Institute of Architects, 1971).

(2) Real estate statistics obtainable in virtually every community, show high rates of movement within a community (as well as from one community to another). In addition, some reports include numerous moves within the same (small) zone in a city. Together, this demonstrates high demand for different physical facilities -- even higher than demand for different neighborhoods and neighborhood services or, conversely, the inability of existing facilities to significantly change in response to user needs changes.

(3) One abundant source of obsolescence literature may be obtained from the Educational Facilities Planning Staff, Erickson Hall, Michigan State University. The literature includes books describing the phenomenon, obsolescence evaluation instruments, charts in which the "leave alone/remodel/rebuild" options can be costed and compared. Other building obsolescence literature is available from U. S. Government agencies concerned with inner city rebuilding and/or rehabilitation.

DESIGN RESEARCH AND EDUCATION: ISSUES AND DIRECTIONS

28: DESIGN EDUCATION

MULTI-MEDIA EDUCATION PACKAGES FOR PROMOTING LAYMAN PARTICIPATION IN ENVIRONMENTAL DESIGN

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The Open University is a nation-wide experiment in providing university-level education for students in full-time occupations, through the use of remote-teaching media. Principally, the media used have been correspondence units of printed booklets plus weekly television and radio programmes. The teaching material is produced centrally by full-time academic and production staff at the University's headquarters, but there is also a regionalised organisation providing back-up tutorial, assessment and student counselling services. In theory, the Open University provides mass education. In practice, its registered student numbers are expected to be limited to approximately 40,000, although perhaps twice this number may purchase its correspondence units (available through bookshops) and watch its TV programmes (broadcast nationally in the early evenings).

The Design Group is a teaching discipline within the Faculty of Technology of the Open University, which has perhaps a unique opportunity for extending design education into new areas of social technology, the de-professionalising of environmental design and multi-media remote-learning packages. This opportunity arises because the Design Group will function at the union of three particular fields of interest. Firstly, the Group is one of five disciplines forming the Faculty of Technology, which is determined not to be only a straight engineering faculty (witness, for one thing, its willingness to house such as the presently-constituted Design Group), but to be concerned at all points with problems of the social and environmental impacts of technology. Secondly, the Design Group already has strong interests in new approaches to environmental design which would make the design and planning processes more public. Thirdly, simply by being part of the Open University, we are committed to developing educational packages for the many thousands of students collecting home-study credits for their degrees. These are broadly-based general degrees, and we are not providing a professional design course.

Social Technology

We use technology to distance ourselves from the trials of survival in the natural environment. In doing so, we create two problematical interfaces: one between our technology and the natural environment, and one between our technology and ourselves. It is at these twin interfaces that we are beginning to recognize massive problems which have become critical in modern society because of the current stage of technological development. At the one interface we have problems such as pollution, ecological disaster and the depletion of natural resources, and at the other interface we have problems such as urban decay, social dislocation and death by accident.

Some people would suggest that these kinds of problem are only transient, to be solved by further technological development, or are "the price of progress." Many other people, however, now seriously question whether economic growth and technological progress are really worthwhile in view of the "price" we are currently being asked to pay.

But are the problems of technology's interfaces really inevitable? Perhaps we have been too ready to assume that the "side-effects" of technological progress are too difficult to predict and control. Certainly Nader's (1) exposure of the "designed-in-dangers" of the motor-car has shown that many accidental deaths and injuries, which we might have assumed to be merely unfortunate side-effects of motor transport technology, are in fact the direct result of poor design. Which suggests that perhaps many "unfortunate side-effects" we are currently expected to tolerate in using our technology are design errors which could be avoided.

There is a real need for the extension of design education into these problem areas at the interfaces of technology. Design is not a personal activity, it is a social activity. It is the decision-making at the interfaces between technology and the environment and between technology and society.

Design Participation

In architecture and urban design, the unequal battle between those who are planners and those who are planned can, on occasion, amount to a conflict between opposing cultures. At best, the layman's view of the decisions handed down by the designers of his environment is of a mixed blessing. Every new development proposal seems to hold as many threats of harmful side-effects as it holds promises for the enhancement of society: a typical current British example is the urban motorway, which may be (temporarily) heaven for the motorist, but hell for the local resident who has to have the motorway a few feet from his bedroom window.

Too frequently, the most that the affected layman can do is to protest when it is already too late. Not only is he not consulted about proposed developments in his neighbourhood, but the planning and decision-making are often made in deliberate semi-secrecy. The layman, with his seemingly low-level objectives (he wants to know how the plans are going to affect him), would be an unwelcome intrusion into the environmental design and planning processes, where totally different sets of objectives and value systems operate.

It has become popular, however, to call for citizen participation in planning. There is certainly a need for new approaches to design if we are to overcome the escalating problems of our technology interfaces, and citizen participation, by involving in the design process those who will be affected by its outcome, may provide a means for removing, at their source, many of the problems arising from the social impact of change and development. But there remains the problem of persuading the layman actually to participate in unfamiliar design processes, which must seem to him to be abstract, secretive and mystical. In addition, many designers must resent the prospect of interference in these design processes which they themselves had to learn to operate by a rigorous professional training.

But one hope is that this gulf between lay and professional involvements in design may be bridged by the evolving new design methods. These new methods (and including the computer-aided techniques) may have been originally developed as attempts to make the design process more rational, but their effect has been to make the design process more public.

In his design methods textbook, Jones (2) has presented these new methods, the "seeds of human futures", as a potential key to solving both the large-scale problems of the man-made world and the problems of wider design participation. "Perhaps the most obvious sign that we need better methods of designing and planning", he suggests, "is the existence, in industrial countries, of massive unsolved problems that have been created by the use of man-made things, e.g. traffic congestion, parking problems, road accidents, airport congestion, airport noise, urban decay and chronic shortages of such services as medical treatment, mass education and crime detection." A central feature of the new methods for tackling these problems is that they are all "attempts to make public the hitherto private thinking of designers; to externalise the design process.... A major advantage of bringing design thinking into the open is that other people, such as users, can see what is going on and contribute to it information and insights that are outside the designer's knowledge and experience."

So far, the design methods field has remained the prerogative of an inter-professional sub-group of designers, the "design-methodologists", and its impact has been disappointingly slight. In design education, "design methods" has often been tacked on as an extra subject, or considered a post-graduate study, but hopefully it may yet be developed as a replacement for the mystique and trial-and-error by which students are currently expected to learn how to design. Alternatively, a possibility which could bridge the gap between "designer" and "user", would be to include design methods as a part of general education in schools, colleges and universities.

Many designers will see such developments and proposals as threats to their professional responsibilities and roles in society. But it is just these professional designers who have failed in the responsibilities, which they assumed for themselves, to guide, control and develop technology for the benefit of society. It is time that we questioned the concept of design education as a training in narrow professionalism.

Packaged Education

It is not only in design fields that traditional concepts of professionalism are being questioned. All professions are meeting criticism for their failures to meet demands for their services, or for the shortcomings of those services they do provide. In particular, that profession which we are all coerced into making increasing use of, the teaching profession, is subject to mounting criticism of the basic concepts it adheres to in dispensing its compulsory services. Schools, and "schooling", it is suggested by the radical educationists, have an anti-educational effect.

A noted critic of the school system, Ivan Illich, (3) has called for the de-schooling of society, to rob the school "priestdom" of its hold on society, as disestablishment robbed the Church of its power. "Schools are designed on the assumption that there is a secret to everything in life, that the quality of life depends on knowing that secret, that secrets can be known only in orderly successions, and that only teachers can properly reveal those secrets"(4).

The radical educationists have realised, with McLuhan, that "the medium is the message". That what students learn is what they do, and that what students principally do - at all levels of the school/college/university system - is to sit and listen to teacher and passively receive "knowledge". "It is safe to say that just about the only learning that occurs in classrooms is that which is communicated by the structure of the classroom itself" (5).

It has been suggested (6) that"packaging" education-independent student use of resource materials, tapes and broadcasts - inevitably radicalises the student role by shifting the emphasis from "I am taught" to "I learn". However, this must largely be wishful thinking, because the medium is still the message, and if the medium is still essentially a distribution of "knowledge"from those who know to those who don't know, in carefully structured and programmed increments, then the message is still that learning is passive reception.

In preparing multi-media packages for design students, therefore, we will still have to be careful that our medium conveys an appropriate message. This is particularly important in design education, since all commentators seem agreed that the design process is itself a learning process. So the message that design students must get is that they learn how to learn. The challenge for our Design Group is to devise educational packages and media mixes which de-professionalise (de-school) design education, so that learning to design becomes an activity open to all, and, in turn, designing itself becomes de-professionalised.

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STATUS AND TRENDS IN DISSERTATION CONTENT AND PROGRAMS FOR DOCTORAL STUDIES IN ARCHITECTURE

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Introduction

The study (1) reported in this paper attempts to remedy in part the woeful lack of organized information on doctoral studies in architecture. This lack was vividly sensed during the deliberations in which the author participated and which led to the formulation of a program of doctoral studies in Architecture (2), and its adoption at Berkeley in 1968. It is partly due to the small number of existing doctoral programs in Architecture, and partly to the insignificant production in terms of graduating doctors from these programs in the United States, a situation which led to the inclusion of these graduates in broader entities such as the Humanities, the Social Sciences, or the Professions in most surveys of graduate education.

Leading statistical reports such as the 1963 report on Doctorate Production (3), and the 1967 report on Doctorate Recipients (4) in U.S. Universities did not show a special classification for Architecture. Specific doctoral programs in Architecture were described in the 4th. Edition, 1969, of "A Guide to Graduate Studies" (5). They included five programs leading to the Ph.D. in Architecture at U.C. Berkeley, Columbia, Illinois Institute of Technology, Pennsylvania, and Princeton, a Ph.D. program in Architectural History at Cornell, and two programs leading to the degree Doctor of Architecture at Michigan and the Catholic University of America.

Correspondence with these institutions and others, as well as information obtained from other sources indicate that the overall picture is undergoing dramatic change. While long established programs at Harvard and the Catholic University of America are inactive or suspended, new programs are being established with considerable enthusiasm at Berkeley, Cornell, and Michigan, others are continuing with strength in Pennsylvania and Princeton, are receiving new directions at Columbia, or are projected for the near future at UCLA. Architectural education itself is undergoing dramatic changes (6) with increasingly growing emphasis on graduate studies, research, and redefinition of goals and methods.

Similarly dramatic changes are occurring abroad with an entirely new orientation appearing in London, a novel framework for architectural education nationally enforced in France, and thorough revisions completed or under way in Australia, Austria, Switzerland, and Sweden. The time seemed ripe for an investigation of these changes, especially in institutions where doctoral degrees are offered.

Of more importance than the information on the institutions, on program administration, and on the production of graduating doctors, is of course the content of the program offerings with the resulting content of dissertations. Information available on these items is not organized, but rather scattered in too many places.

The original study briefly reported here covers a systematic description of those institutions here and abroad in the Western World offering doctoral programs in architecture, the content and method of administration of their programs, and the dissertations produced or proposed in them. It also includes representative examples of dissertations produced in departments other than architecture, but which deal with subjects related to the interests of architects.

Objectives of the Study

The study has the following general objectives:

1. To collect information on programs offered at institutions granting doctoral degrees in architecture, including their academic requirements and program content, also on the research activities of the described institutions.

2. To seek out titles of doctoral dissertations recently completed in architecture, or in other academic departments but with an architecturally related content.

3. To organize the material collected under 1 and 2 on institutions in the United States, the British Commonwealth, and Western Europe, in a consistent manner for ease of comparison.

4. To develop master lists for dissertation content from an analysis of the collected titles and related abstracts where available, and to examine the distribution of dissertations over items of the master lists.

The Survey

The survey portion of the project comprised the following steps.

Published announcements of institutions offering curricula in Architecture were collected and examined. Letters were sent to institutions known to have, to have had, or likely to have offerings at doctoral level in Architecture, with particular emphasis on a request for information on completed as well as current dissertations.

Published dissertation abstracts series in the named countries were consulted to extract information on dissertations completed in schools of architecture, or having an architectural content. Wherever possible English texts were secured, and, where necessary, translations were made of the texts published in another language.

A total of 417 titles of dissertations or proposals appear in the original report. Their distribution (see Table 1) is as follows: 141 in the United States, 30 of them completed or proposed in five architectural departments; 75 in the United Kingdom, 67 of them in 7 architectural schools; 38 in three architectural schools in Australia; 130 in West Germany with 118 of them completed in 8 architectural schools; 14 in Switzerland, 17 in Denmark, and 2 in Norway, with one school in each country.

Of the total 417 titles, 131 were completed in departments other than architecture, 111 of them in some 20 department categories in 51 Universities in the United States. The balance of the total comprises 197 dissertations completed in 19 architectural schools, and 89 current proposals lodged in 9 architectural schools.

The survey showed doctoral programs in existence in architectural schools for which no information could be secured on titles of completed dissertations or on current proposals. The original report includes available descriptions of such programs in four American schools, in a number of British and Australian schools, and in schools in Austria, Sweden, Finland, France, Hungary, Italy, the Netherlands, and Spain.

In the cases of dissertations completed or proposed in architectural schools, all known titles of work currently in progress, and all those of dissertations reported to have been completed since 1965 were selected for the study. In a few cases, some of the dissertations completed earlier than 1965, i.e. between 1962 and 1965, were also included where necessary to give a better picture of the topic coverage in the school. In schools offering programs embracing many topics other than architecture, the choice was restricted to a selective list. Similarly for dissertations completed in departments other than architecture, the selection of titles was made to give as broad a coverage as possible in the institutions and department categories represented, to insure a wide coverage of topical subjects relevant to the interests of architects, to avoid over representation of rich categories and to limit the examples in clearly peripheral areas of interest.

Organization of Material

The original report includes a whole Part (II) organized to show the results of the survey by institution and country. Institutions in 15 countries are described separately, each with an opening statement on some outstanding feature, followed by sections on undergraduate and graduate degrees, dissertations, research activities, and references to sources of information.

For each degree offered, a summary is given of the prerequisites for admission, and of the requirements for completion. Each dissertation entry shows the author's name when known, the title of the dissertation, the year of completion, a serial number of identification, and a three-character alpha-numeric symbol related to the content of the dissertation.

The dissertations completed in departments other than architecture are placed in one section for each country, and are grouped by department category for the United States. The names of departments and institutions are shown with each dissertation entry.

The above information is too bulky to be included in this paper, but could be obtained from the original report referred to above.

Dissertation Content

In the early stages of the study, a master list for topic areas in doctoral dissertations was drawn, initially based on the program content description of recent programs in the United States, especially the one at Berkeley. The master list was refined, added to, and amended as the study progressed. The final list used for coding is shown in Table 2. It comprises six major topic areas referred to by capital letters A to F, each subdivided into 3 to 8 categories referred to by a single digit. Each of these categories may comprise a single item or a group of items forming reasonable clusters.

Another list was compiled for the kinds of buildings or other contexts to which the dissertations refer. The list, shown in Table 3, comprises 14 groupings each referred to by a lower-case letter from a to n.

These two lists make it possible to give each dissertation entry, in addition to a serial identification number, a code symbol composed of three characters: A capital letter (from A to F) denoting a main topic area, a digit number from 1 to 8 referring to sub-categories within the main topic areas (see Table 2 for both), and a lower-case letter indicating the building type or other context to which the dissertation relates (see Table 3).

This system of coding made it possible to compile an Index for titles of all dissertations and proposals having identical three-character alpha-numeric symbols, i.e. those titles falling in a certain sub-category within a main topic area and relating to a certain context or building type.

A condensed picture of the content of all dissertations and proposals is shown in Table 4 which gives the number of dissertations and proposal entries for each sub-category within each main topic area, and with respect to each building type or context. The table also gives sub-totals and totals for columns and rows.

Doctoral Programs

Probably the best way to get acquainted with the characteristics of the various doctoral programs in architecture is to browse through the descriptions of the institutions listed in Part II of the original report. From this reading, certain patterns may emerge, and some of these are discussed here.

It seems clear that architectural schools in the United States, so far, and on the whole, have not been very keen on encouraging doctoral studies in architecture. English and German schools have a much better record in this respect. Many of them have produced a respectable number of doctors in recent years while the American production has been minimal.

An emerging rekindling of interest is discernible in the United States, as witnessed by newer programs appearing in a number of architectural schools such as Berkeley, Cornell, and Michigan, and by some joint programs administered by other departments in collaboration with architecture, such as the program of Architectural Psychology at Utah, and the program in Classical Archaeology at Columbia.

American programs differ from their counterparts in Europe in some respects, and are similar in others, although the overall intent and final results may be comparable. The main distinction lies in the fact that American programs tend to be more articulate in specifying the goals, and in charting the course to be followed to reach them, while the European programs, and especially the German ones, maintain a deliberate vagueness on the course of action.

For example, most American programs describe with some care the steps leading to a candidate's admission, the various tasks expected for his initial screening, and for the method of gauging his progress and preparation through a qualifying examination. They also usually give the candidate the privilege of selecting or at least proposing a committee of advisers and examiners, and great latitude in the selection of courses in consultation with his main adviser. In the preparation of the dissertation, he has the benefit of consultations with a committee of thesis advisers.

Thus, there is a kind of contract between the candidate and the institution, each undertaking to ensure the quality of the educational process which then, it is assumed, will naturally lead to the quality of the end product, the dissertation. The American schools are also varied in the kinds of interests they pursue, and these are reflected in the content of their programs, and the composition of their faculties.

In the German system, federally accepted standards are uniformly applied in most schools, the intent being to ensure a uniform standard of quality of education in the country, and to allow transfers from an institution to another without discontinuity or loss of time. As a result, this framework somewhat discourages variation and innovation. A doctoral candidate works with a supervisor who directs his course of study, evaluates his progress, and approves the dissertation draft prior to submission to an examining board. Sometimes, more than one supervisor is assigned to the candidate, and they follow tacitly agreed upon norms in directing the work of their advisee.

In other words, there is less dependence on an articulated process, more reliance on the wisdom of the supervisors, and on the quality of the end product, the thesis or dissertation. To insure its quality, the dissertation is scrutinized by an examination committee, and must be defended publicly in a presentation to a faculty board.

In almost all programs, there is an expectation that the candidate must demonstrate mastery of his field of specialization, as well as a broadly based knowledge of the discipline of architecture and of the ramifications of his own specialization on other aspects of the discipline. He must demonstrate his capacity to undertake independent research, and the results of his research are incorporated in the dissertation.

American programs usually require examinations in a major field and in one or more minor fields, and a reading knowledge of one or two foreign languages. Many programs in other countries are silent on these matters, although similar requirements may tacitly be expected or enforced. There may be less need to specify a language requirement in a country where every student learns one or two foreign languages in grade school, or where the requirement is enforced as a condition for admission to the University.

In many countries, doctoral studies in architecture are reserved to candidates holding a first professional degree in architecture, some programs also require the acquisition of the degree Master of Architecture prior to formal admission to doctoral studies. This pattern is changing slowly, affected by the same currents that are forcing changes at all levels of architectural education. Recently formulated programs have been more liberal in describing the kind of candidate who can gain admission, while maintaining the required standards of intellectual aptitude and/or academic performance. In most cases where non-professional candidates are admitted, certain requirements are added to ensure that the candidate is adequately familiar with the methods of operation and the main concerns of the discipline of architecture.

A subject of relevance in this respect is the emergence of other non-professional programs in architecture, or the revival of older ones, both at undergraduate (B.A. or A.B.), and graduate (M.A.) level. These degrees, administered by parent bodies such as a Faculty of Letters and Sciences, or a college of Environmental Design, incorporate a major in architecture. They imply a broad education, with a major interest in architecture and in some broad social problem connected with the field, but not to the extent normally expected in a professional degree.

There are several varieties of degrees now granted at doctoral level, each carrying a different name, and conveying a different connotation. The Ph.D. (Doctor of Philosophy) degree in Architecture is an academic degree, not a professional one. It implies broad education, excellence in scholarly achievement and research. Foreign languages, facility in written expression, and extensive reading in the field are naturally expected. The degree Doctor of Architecture implies professionalism, in the sense of more professional education, and/or more expertise in a professional specialization. Language and broad education become of secondary importance.

The degrees Doctor-Engineer (Dr.Ing.), and Doctor in Technology (Dr.Tech.) are variants of the degree Doctor of Architecture granted in certain European countries like Germany, Switzerland, and Scandinavian countries. They imply a more technical orientation. The degree Doctorat, with the title Doctor and appropriate additives, is used in France to designate corresponding levels of graduate education. In Spain, the degree of Doctor is meant to correspond with the intent of a Ph.D. degree. In Italy, the first professional degree in architecture is called a Laurea and confers on its bearer the title Dottore, not to be confused with the Doctoral degrees dealt with in this study.

In German and Scandinavian programs, studies following the Doctor's degree may lead to the preparation of a second thesis and to earning a further degree called Habilitation. In American Universities, post-doctoral studies in Architecture are possible, but uncommon; they are usually meant to allow individual study and research, and do not lead to a further degree. In some foreign Universities, Melbourne being an example, pre-eminence in the field and personal research supported by a suitable exhibit or unpublished material may earn the applicant the degree Doctor of Architecture.

A class of doctoral degrees, usually administered by departments other than architecture, or in collaboration with these departments, bear names in which reference is made to architecture. Examples of these are the Ph.D. in Architectural Engineering, to be found in Sydney, Australia and many other places, and the previously mentioned Ph.D. Architectural Psychology of Utah. Other programs are administered by departments housed together with architecture in Colleges or other administrative units. This fosters a close relationship between departments, so that some of the dissertations completed in other departments may have an architectural input.

Analysis of Dissertation Content

As mentioned earlier, Part II of the original study reported in this paper lists 417 titles of dissertations and proposals which offer the reader a condensed view of the content of recent doctoral work in architecture and related fields.

In order to obtain a more detailed description of dissertation content, one may refer to the items mentioned in the reference list to know the source of information used, and then trace the abstract related to the particular title in the corresponding volume of dissertation abstracts. An even more complete information may of course be had by ordering copies of the original dissertations from the commercial concerns specializing in this kind of service, or through special arrangement of library loan service. For current proposals, details of their content could probably be obtained by writing their authors or the departments in which they are pursued.

The study reported here is interested in an overall view of the content of recent doctoral dissertations and proposals, and for this purpose, the compendium of titles may be sufficient. However, in translating the content of dissertations into symbols, the dissertation abstracts or other descriptions when available were read prior to ascribing a particular set of symbols.

Naturally the selection represents the author's judgment which may be disputed in cases where the dissertations deal with several subjects simultaneously.

The tables included in this paper are but a few, and in certain cases, composite constructions of the eleven tables included in the original study. From these tables, numerous observations were made in the body of the original report, some of which are summarized here.

Looking at Tables 2 or 4, one may notice that main topic areas A, B, and C account for the bulk of all titles, actually 351 titles, or 84.2% of the total, while areas D, E, and F combined account for only 66 entries or 15.8% of the total. When current proposals only are considered, topic areas A, B, and C account for 77 titles, or 86.5%, while the titles in areas D, E, and F dwindle to 12 or 13.5% of the total.

One may also notice that Area B, History and philosophy of architecture, which ranks highest for all entries, falls to 3rd rank when current proposals only are considered, while Area A, Architectural design and design process, moves up from third place in all entries to first place in current proposals. Area C, Technology emphasis in architecture, remains second in both cases.

Turning now to Table 3, which lists the building types or other contexts to which dissertations relate, one may find that the largest single category for all entries, as well as for all proposals, is "n," general, with no particular reference to a building type or other context. One may also see that this category jumps from 88/417 or 21.1% of the total for all entries to 34/89 or 38.2% of the total for proposals only. This may be explained by the fact that many candidates are in the process of developing their proposals and may not yet have reached a decision on the precise relation of their subject matter to a particular building type or context. It may also mean that general and abstract subjects are gaining in popularity.

Following "n," the categories with highest scores are "a," residential, "c," cities, "b," structures, "d," educational, and "e," religious, when all entries are considered. For proposals only, categories "c," and "a," remain in the lead, but a sharp decline occurs in "b," engineering structures, and "e," religious buildings. The decline is even more dramatic in "d," educational buildings which appears in only a tiny minority of current proposals.

Looking next at the 30 sub-categories of main topic areas listed in Table 2, one finds that 7 sub-categories alone account for 57.1% of all entries. They are sub-categories "B1," History of architecture, "A1," Case studies, "C1," Structure, "C2," Environmental controls, "B2," Biographies, "A2," Urban design, and "A4," Design process.

For proposals only, five sub-categories, C2, B1, A4, A1, and A2, are in the lead, collecting 42 titles, or 47.2% of the total. Environmental controls form the most popular category, followed by History of architecture, Design process, Case studies, and Urban design. Two of the leading sub-categories in all entries do not appear at all in current proposals, namely "C1," Structures, and "B2," Biographies.

A close examination of the totaled rows in Table 4 yields additional observations. The said rows show the numbers of entries in a main topic area related to specific building types or other contexts. The highest score here is 44, received by "Cb," Technology of engineering structures, followed by "Be," History of religious buildings, and by "Bn," History of architecture, general. The corresponding high scores for proposals are: Highest, "An," Architectural design and design process, general, followed by "Cn," Technology in architecture, general, and "Bn," History of architecture, general.

Four combinations appearing in the highest-score items for all entries do not fare well in the corresponding scores for proposals. They are "Be," History of religious buildings, "Ad," Architectural design in educational buildings, "Cc," Technology in cities, regions, urban complexes, and "Bf," History of public and civic buildings. Interest in these areas must have ebbed in current proposals. To compensate, two new areas appear with substantial showing in current proposals, after having trailed in all entries. They are "Ca," Technology in residential buildings, and "Ac," Architectural design in cities, regions, and urban complexes.

A similar examination of all other rows in Table 4 may lead to further observations concerning the occurrence of titles in sub-categories of the main topic areas as they relate to building types or other contexts. In this respect, the highest score for all entries is received by Structure in engineering work, followed by History of religious buildings, of residential buildings, and of architecture in general. For proposals only, the highest score is received by Design process, methodology, general.

Certain combinations represent areas considered highly important and attractive in recent years, but no longer enjoying the same popularity among current candidates proposing titles for their dissertations. They include, among others, "C1b," Structure in engineering work, "B1e," History of religious buildings, "A1d," Case studies of educational buildings, and "B2n," Biographies, general. On the other hand, new combinations have appeared in the top-list of current proposals, therefore seemingly enjoying some popularity among current candidates, while they trail in the top list for all entries, therefore indicating that authors of completed dissertations did not care for these areas so much. They include "A8n," Communication, etc., general, and "C2g," Environmental controls in health related buildings.

Certain combinations maintain a strong showing for all entries as well as proposals. They are "A4n," Design process, methodology, general, "A2c," Urban design in cities, "B1n," History of architecture, general, "B3c," History of urban development in cities, and "C2n," Environmental controls and factors, general.

Concluding Remarks

The author has refrained from making a case for increased attention, care, and support for Ph.D. programs in architecture, but hopes that factual evidence on the existing situation as described in this report will contribute to making such a need clear enough. Anxieties resulting from the glut of doctors in other fields cannot apply to the burgeoning production of doctoral graduates in Architecture. The paucity of American programs and of American production in doctoral studies in Architecture should be evident, all the more so when compared with the long-established record and the current production abroad, and when measured against the needs of the discipline.

Much of the American production in dissertations related to architecture comes from departments other than architecture. There is no reason, other than will and resources, why a similar production should not be generated in schools of architecture in collaboration with other departments of the university campuses. In fact there is much to be gained by injecting the perspective of an architectural point of view.

Beyond questions of competing places, there is the more basic question of the need for research in architectural schools to fill the demands of an evolving discipline, to serve and help improve the profession, and to produce the generation of needed specialists, researchers, and educators, all well versed in the rigors of research, who would be filling the cadres of our schools and research institutes, and who would provide the professional offices with the expertise of their specializations.

There seems to be in the United States now a renewed interest in doctoral studies that may presage an era of unprecedented expansion in doctoral programs and in the production of doctors and dissertations in architecture. The reported study takes stock of the situation as it appears now at the threshold of this era of anticipated expansion.

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TABLE 1 - Listed dissertations distributed by institutions, degree and place of completion

Institution and Country	Proposals in progress in architectural schools	Dissertations completed in architectural schools	Dissertations completed in other departments	Total
University of California, Berkeley, California	20	-	-	20
Cornell University, Ithaca, New York	1	-	-	1
University of Michigan, Ann Arbor, Michigan	3	-	-	3
University of Pennsylvania, Philadelphia, Penn.	-	5	-	5
Princeton University, Princeton, New Jersey	1	-	-	1
United States - Other	-	-	111	111
United States - Total	25	5	111	141
University of Edinburgh, Edinburgh	-	16	-	16
University of Strathclyde, Glasgow, Scotland	-	5	-	5
University of Liverpool, Liverpool	-	6	-	6
University College, School of Environmental Studies, London	15	6	-	21
University of Manchester, Manchester	-	7	-	7
University of Sheffield, Sheffield	6	5	-	11
University of York, Inst.Adv.Arch.Stud., York	-	1	-	1
United Kingdon - Other	-	-	8	8
United Kingdom - Total	21	46	8	75
University of Melbourne, Victoria	2	2	-	4
University of New South Wales, Kensington	18	1	-	19
University of Sydney, N.S.W.	9	6	-	15
Australia - Total	29	9	-	38
Technical University, Aachen	-	24	-	24
Technical University, Berlin	-	19	-	19
Technical University C.Wilhelmina, Braunschweig	-	14	-	14
Technical University, Darmstadt	-	2	-	2
Technical University, Hannover	-	16	-	16
Technical University, U.Fridericiana, Karlsruhe	-	14	-	14
Technical University, Munich	-	20	-	20
University of Stuttgart	-	9	-	9
West Germany - Other	-	-	12	12
West Germany - Total	-	118	12	130
Swiss Federal Institute of Technology,Zurich	-	14	-	14
Switzerland - Total	-	14	-	14
Royal Danish Academy of Fine Arts,Copenhagen	14	3	-	17
Denmark - Total	14	3	-	17
The Technical University of Norway, Trondheim	-	2	-	2
Norway - Total	-	2	-	2
Totals	89	197	131	417

TABLE 2 - Listed dissertations distributed by main topic areas and their sub-categories

Main topic areas and sub-categories	Proposals only	Total titles
A. Architectural Design and Design Process		
1. Case studies, building and parts types, comparative studies.	7	38
2. Urban design, city planning, landscape design, space design, land use, densities, location, subdivision.	6	20
3. Programming, planning for buildings, standards, space allocation.	2	13
4. Design process, design methodology, linear programming, gaming, simulations, mathematical models.	9	16
5. Performance of buildings and space, architectural criticism.	3	8
6. Design theory and principles, heuristics, flexibility, modules.	1	6
7. Teaching architecture including design, student performance.	2	3
8. Communication, information, symbols, pattern language	4	5
Totals	34	109
B. History and Philosophy of Architecture		
1. History of architecture.	9	77
2. Biographies or work of specific architects.	1	21
3. History of urban development.	4	12
4. Aesthetics, history of art and technology.	-	8
5. Conservation, restoration, documentation, archaeological digs.	2	5
6. Theory or philosophy of architecture.	-	3
Totals	16	126
C. Technology Emphasis in Architecture		
1. Structures, stress models, soil technology.	2	33
2. Environmental controls and factors, climate, airflow, lighting, energy, noise, comfort conditions.	11	33
3. Material technology, performance criteria, production of materials and of buildings.	4	10
4. Resource protection, soil drainage, sewage treatment, hydraulics.	3	5
5. Technology of construction systems, equipment, furniture.	2	14
6. Building process, industrialization, organization of building sites, erection techniques.	2	7
7. Transportation, traffic, road construction.	3	14
Totals	27	116
D. Behavioral Science Emphasis in Architecture		
1. Perception of building characteristics, consumer reactions and preferences, clientele identification.	1	10
2. Individual behavior, human factors and psychological implications of building design.	2	9
3. Social behavior and organization, sociology of the profession.	3	9
Totals	6	28
E. Economic Factors in Architecture		
1. Economics of the building industry, market supply and demand, real estate market, consumer economics.	2	7
2. Valuation, efficiency,comparative costs of buildings and parts.	-	7
3. Investment in buildings, taxation, management, maintenance, deterioration, obsolescence.	1	5
Totals	3	19
F. Professional Practice and Architectural Administration		
1. Decision making in relation to client, consultants, agencies, public policy, and architectural controls bodies.	2	11
2. Scope of services, legal aspects, office practice, administration, specifications, contract documents.	1	4
3. Site inspection, surveys, supervision, contractors' relations.	-	4
Totals	3	19
Grand Totals	89	417

TABLE 3 - Listed dissertations distributed by building type or other context to which they relate

Code	Building type or other context	Proposals only	Total titles
a.	Residential buildings, areas, including palaces, hotels.	13	63
b.	Engineering work or structures, soils.	6	52
c.	Cities, regions, urban complexes, open space, landscape, sites, roads.	14	57
d.	Educational buildings.	2	48
e.	Religious buildings, cloisters, mausoleums.	3	31
f.	Public and civic buildings, judicial facilities, museums, theatres, auditoria, historic buildings, citadels, penitentiaries.	3	19
g.	Health related buildings.	4	16
h.	Industrial buildings, warehouses.	3	9
i.	Commercial buildings, office buildings, shops, department stores, broadcasting studios, laundry facilities.	3	8
j.	Interiors, art work.	1	13
k.	Rural buildings.	-	4
l.	Recreational buildings and facilities, community facilities, clubs, tourist facilities, zoos.	2	5
m.	Transportation buildings, parking structures, airports.	1	4
n.	General, no reference to a particular building type or other context.	34	88
	Totals	89	417

TABLE 4 - Distribution of dissertations and proposals by main topic area, by sub-category thereof, and by building type or other context to which they relate

General note - Underlined figures refer to current proposals only.
Note (X) - See Table 2 for topic area codes.
Note (Y) - See Table 3 for building type or other context codes.

Topic Area (Note X)	Building Type or Other Context (Note Y)																													
	a		b		c		d		e		f		g		h		i		j		k		l		m		n		Total	
A1	1	4		-		3		9		-	2	5		6	2	4	1	3		-		-		-		2	1	2	7	38
A2	1	3		-	4	13		2		-		-		1		-		-		-		-		-		-	1	1	6	20
A3		2		-		-		5		-		1	1	2		-		-		-		-	1	3		-		-	2	13
A4		2		-		1	1	1		-		-		-		1	2	2		-		-		-		-	6	9	9	16
A5	1	4		-		-	1	3		-		-		-		-		-		-		-		-		-	1	1	3	8
A6	1	2		-		-		2		-		-		-		1		-		-		-		-		-		1	1	6
A7		-		-		-		-		-		-		-		-		-		-		-		-		-	2	3	2	3
A8		-		-		-		-		-		-		-		-		-		-		-		-		-	4	5	4	5
A Total	4	17		-	4	17	2	22		-	2	6	1	9	2	6	3	5		-		-	1	3		2	15	22	34	109
B1	2	18		2		1		1	2	25		7		1	1	2		1		2		2		1		-	4	14	9	77
B2		2		1		1		-		3		3		-		-		-		1		-		-		1	1	9	1	21
B3		-		-	4	12		-		-		-		-		-		-		-		-		-		-		-	4	12
B4		-		2		-		-		1		1		-		-		-		1		-		-		-		3		8
B5		1		-		-		-	1	1		1		-		-		-		-		-		-		-	1	2	2	5
B6		-		-		-		-		1		-		-		-		-		-		-		-		-		2		3
B Total	2	21		5	4	14		1	3	31		12		1	1	2		1		4		2		1		1	6	30	16	126
C1		-	2	33		-		-		-		-		-		-		-		-		-		-		-		-	2	33
C2	1	2	1	2	1	5		4		-	1	1	3	4		-		-		2		1		-		-	4	12	11	33
C3	2	2		3		-		-		-		-		1		-		-	1	1		-		-		-	1	3	4	10
C4	1	1		1	1	1		1		-		-		-		-		-		-		-	1	1		-		-	3	5
C5		4		4		1		-		-		-		1		-		-		-		-		-		-	2	4	2	14
C6	1	2	1	1		3		-		-		-		-		-		-		-		-		-		-		1	2	7
C7		-		-	1	11		-		-		-		-		-		-		-		-		-	1	1	1	2	3	14
C Total	5	11	4	44	3	21		5		-	1	1	3	6		-		-	1	3		1	1	1	1	1	8	22	27	116
D1		2		-		-		2		-		-		-		-		-		2		-		-		-	1	4	1	10
D2		-		-		-		3		-		-		-		-		1		3		-		-		-	2	2	2	9
D3	1	4		-	2	3		2		-		-		-		-		-		-		-		-		-		-	3	9
D Total	1	6		-	2	3		7		-		-		-		-		1		5		-		-		-	3	6	6	28
E1		4	2	2		-		-		-		-		-		-		-		-		1		-		-		-	2	7
E2		1		-		-		2		-		-		-		1		1		-		-		-		-		2		7
E3	1	1		-		1		1		-		-		-		-		-		1		-		-		-		1	1	5
E Total	1	6	2	2		1		3		-		-		-		1		1		1		1		-		-		3	3	19
F1		1		-		-		7		-		-		-		-		-		-		-		-		-	2	3	2	11
F2		1		-	1	1		2		-		-		-		-		-		-		-		-		-		-	1	4
F3		-		1		-		1		-		-		-		-		-		-		-		-		-		2		4
F Total		2		1	1	1		10		-		-		-		-		-		-		-		-		-	2	5	3	19
Grand Total	13	63	6	52	14	57	2	48	3	31	3	19	4	16	3	9	3	8	1	13		4	2	5	1	4	34	88	89	417

THE ALLIGATOR LEARNING EXPERIENCE
CHILDREN"S STRATEGIES AND APPROACHES TO A DESIGN PROBLEM

Charles Zerner
Thomas C. Hubka

Introductory Note

The Alligator Learning Experience was a pilot study conducted in order to shed light upon children's approaches to design problems. The sole portion of the original study that is reproduced in this collection is the description of methods employed and analysis of the drawings themselves. For reasons of clarity and brevity we have chosen to delete the major (and perhaps most interesting) portions of this study. These deleted portions treated more speculative questions including the notion of the child as a model for certain exemplary features of design behavior and the possible uses of phenomenological analysis and experiential psychology as tools in the education of designers. In lieu of these sections a brief and thoroughly inadequate resume of these issues can be viewed in last half of this paper. The interested reader can obtain a copy of the original working paper entitled: A Phenomenological and Experiential Approach to Design Education: The Alligator Learning Experience by writing to The Center for Environmental Research, Department of Architecture, University of Oregon.

Charles Zerner
Thomas Hubka

Synopsis

A learning experience was conducted with children whose ages ranged from four to seven years of age. The learning experience consisted of the following sequence of events: (1) familiarization with the children, (2) statement of design problem, (3) showing of the movie entitled Prowlers of the Everglades, (4) restatement of design instructions, (5) drawing without interviews, (6) drawing with interviews and documentation. The instructions consisted of statements that asked them to make, by drawing, a dwelling place for the female alligator and her offspring.

Summary of the Characteristics of Children Used in this Pilot Study

The following information summarizes the characteristics of the population of children used in this pilot study.

Nursery School A.

Teacher: Mrs. K. Proportion of Males and Females: 8 males, 7 females.

Age range and frequency:

Frequency	Age
1	3 years old
13	4 years old
1	5 years old

Nursery and elementary school B

Proportion of Males and Female Children: 5 males, 7 females. Age Range and Frequency:

Frequency	Age
1	4 years old
11	5 years old

Elementary school B. Instructor: Miss N. Proportion of Males and Female Children: 14 males, 16 Females. Age Range and Frequency:

Frequency	Age
3	5 years old
22	6 years old

Nursery school C. Director: Mrs. C.

Proportion of Males and Female Children: 8 males, 6 females. Age Range and Frequency:

Frequency	Age
4	4 years old
10	5 years old

Description: Scenario of the Alligator-Learning Experience

Materials: The experience had two main parts, the showing of the movie and a drawing period. We used a 16 mm projector to show a twenty minute portion of the Walt Disney color movie called Prowlers of the Everglades. During the drawing period, a six foot wide sheet of newsprint was taped onto the floor of the nursery or schoolroom. The length of the sheet varied from 12 to 40 feet, depending on the number of children involved in the learning experience.

Magic markers of varying colors were used as drawing instruments. A photo record of portions of the learning experience was obtained with a Cannon 35 mm camera. A Sony tape recorder was occasionally used to tape the interviews with the children.

Procedure: What follows is a brief description of the sequence of events in the learning experience.

Sequence of Operations

a. Familiarization with the Children.

We spent a separate period of time prior to the experience, getting acquainted with the children we were to work with.

b. Statement of the Problem and Showing of the Film.

On the day of the learning experience we would come into the nursery or school room and set up the projector, screen and sound system in the presence of the children.

Showing of the Film Segment

The following is a description of the content of a segment of the film in summary form:

1. Opening shots of alligators yawning, in the water and on the land.

2. Fight between the bull alligators for dominance in mating hierarchy.

3. The female alligator climbs onto the bank to build a nest for the eggs. She lays eggs, covers them with leaves and lies on top of them.

4. The mother alligator leaves nest briefly. She returns to ward off racoons and swamp skunks, which are attempting to eat the eggs.

5. The mother alligator lies on the nest until the newborn alligators hatch.

6. The newborn alligators make their way from the nest into the water. Some of them are eaten by a bull alligator and a family of racoons.

7. The survival of a few young alligators. They have made their way from the nest to the water's edge and begun to swim, staying close to the mother alligator.

c. Restatement of Instructions and Drawing Period

After the projector was stopped, we immediately restated the problem: "Now you can have a chance to make a home for the mommie alligator and her babies."

d. Drawing Period Without Instructions

The children were given a period of approximately five to ten minutes in which they drew without any interruptions.

e. Drawing Period With Interviews.

After the brief period of commencement of drawing, we would get on the floor with the children and talk with them about their drawings and thoughts about the alligators and what kind of home they thought the alligators should have. We allowed the children to continue to draw until they felt they had completed the pictures.

Description and Rationale for the Categories of Analysis Used in Interpreting the Children's Drawings

> "Any number of descriptive labels can be applied to these markings - scribblings, designs, gestalts, motifs, charts, symbols, signs, compositions, abstractions, representations, or pictures. The label depends upon who does the labeling and in what context the work is viewed."
>
> Rhoda Kellogg, Understanding Children's Art. p. 33 Readings in Developmental Psychology Today. Phebe Cramer, Editor.

In the following section the drawings of the children are described and evaluated. After inspecting the results of our learning experience, four categories or dimensions of analysis were selected as appropriate for a useful description of the drawings. These categories are enumerated below with a brief discussion of the rationales for their formation. Before entering, however, into a resume of these categories, it is useful to remind the reader of our central research concerns. As stated in the introduction, these concerns are 1) the developmental aspects of creation, and design in particular, 2) the importance of restructuring design curriculum in such a way as to make the designer more responsive to the experiential dimensions of space, and 3) the application of a phenomenological or "experiential" view of design processes, or the problem of entering into the life situation (needs, desires, "constraints") of another person.

What follows is an attempt to shed light upon themes (1) and (3) in particular. A detailed consideration of the implications of the results of this learning experience in relation to the restructuring of design curriculum follows this.

Categories of Analysis

In the selection of categories of analysis, particular attention was focused upon two themes, (a) those features of the children's drawings which were particularly and peculiarly rooted in a child's representation of a dwelling place within an environment, and (b) the strategies of design that the children employed in dealing with the creation of a dwelling place. In regard to the theme (a) our discussion evaluates, in a summary manner, those particularly childlike" features of the representations of dwelling places and environments (as opposed to an "adult" or technical rendering). This learning experience is not an experiment, by any means, in developmental psychology.

We were primarily interested in those strategies of design that the children used in making a home for the female alligator and her babies. This last consideration, the notion of strategies involved in creating a design solution, is probably the dimension of our analysis that is most germane to our interests as students of architectural education. How did the children "solve" the problem of protection from the skunk and racoon? That is, how did the children deal with particular environmental constraints in designing a house or nest? What features of the alligator's life patterns did the child attend to? What features of the site are deemed significant in making a home? With the above considerations in mind, the following four categories of analysis were selected: (a) Strategies of Site Selection, (b) Strategies of Form, (3) Environmental Constraints, and (d) Features of Early Developmental Level of Cognition and Representation.

a. Strategies of Site Selection

We considered the conception and use of the site as a significant feature of the children's drawings. After reviewing the children's representations of dwelling places, it was observed that site selection was actually used as a significant variable in designing the home of the alligator. We characterize this differential use of site as a design strategy, for it represented one means whereby the children arrive at a design solution that protected the young alligators from predators. There were marked differences in the articulation, differentiation and use of the site or context of the alligator home in the drawings of the four year olds as contrasted to those of the older children. Further, in the case of the older children, there were significant variations within this group in the way sites were used. In fact, variation of site or context for the dwelling place was a major theme in the older children's drawings.

b. Strategies of Form

A great variation in the kinds of structures (or lack of structures) was found in the children's representations. The children's use of a variety of forms and structures is, prima facie, a form of design strategy. Two major classes of forms strategies comprise the basis of our analysis: (a) the representation of materials and structures that are distinctly man-made, and (b) the representations of forms and elements of the natural landscape.

c. Environmental Constraints

The Problem of the Skunk and Racoon as Predators.

The two strategies treated above, strategies of site variation and strategies of form, are intimately connected to the children's conception and articulation of the predators. It is apparent that the degree to which the child is capable of differentiating the habits and life patterns of the skunk and racoon from the range of animal life inhabiting the swamp represents a crucial cognitive factor in the child's design solution. It might be said that the degree of pictorial specificity and differentiation of the predators is a good clue to the child's conception of the design problem as a whole. In comparing the drawings of the youngest children with those of the older children, we found marked differences in the articulation and specificity of the representations of the predators. This increasing differentiation and articulation of the characteristics of the predators is concommitant with an increasing differentiation and specificity of alligator dwelling places.

d. Features of an Early Developmental Level of Cognition and Representation:

A recurrent feature of the children's solutions to the problem of design consisted of conjunctions and linkages that would be considered "illogical", "unrealistic", "anthropomorphic" or "animistic" to the student of child development. "Illogical" or "unrealistic" fusions of distinct realms of the natural and human environment (syncretic thought) were characteristic of many solutions to the problem. Also evident was an "ecocentric" mode of representation. That is, the children viewed the world, and the capabilities of the alligator in particular, as if they functioned in the way the child himself, as a human being, would operate. Finally, the children proposed some solutions that were based on an "animistic" view of the world. These features of early cognitive development, syncretism diffuse or undifferentiated representations, egocentricity and pre-operational, animistic thought, entered into many of the children's representations. Our analysis of these features of the representations is merely a descriptive summary; we borrow our terms and concepts from the works of Jean Piaget[1], Mircea Eliade,[2] Heinz Werner[3] and Ernest Cassirrer.[4]

A few words of caution to the reader are necessary before the analysis of drawings is begun. Our categories are provisional in nature. They are merely an attempt to (1) delve into the design strategies of the child and (2) to shed light upon the process of design in general.

Secondly, we are immersed in troubled waters, as it were, in using the terms "conception", as in "the child's conception of the site." Our only empirical evidence for conceptual strategies are the drawings themselves and our interviews with the children. We are making an inferential leap when we jump from the realm of representation to the realm of concepts.[5]

Analysis of Younger Children's Drawings

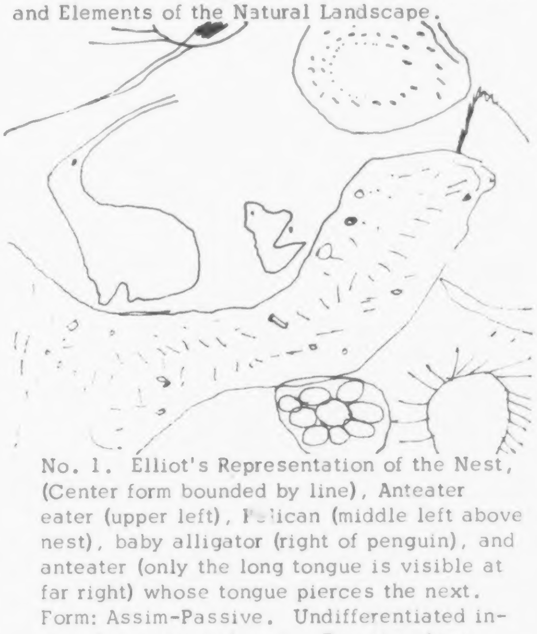
a. Strategies of Site Selection.

While this category of analysis is uniquely appropriate in relation to the drawings of the older children, it is not particularly suited to a description of the younger children's representation. The most characteristic feature of (a) the site proper and (b) the relationship between site and alligator dwelling in these representations is a lack of articulation and differentiation. In most representations there is no indication of the locus or zone of the nest or home. Most of the dwellings depicted to not exist in a milieu or particular area of the environment. Consequently there is a diffuse or inarticulated relationship between the dwelling and its site. The typical representation consisted of a roughly circular form that bounded the eggs. This line constituted the boundary of the nest, the eggs (smaller circles or ovals) being inside this circular form.

The predators were usually placed outside of this boundary line. (see illustrations 1 & 2) We might infer from the lack of any specific environmental or contextual features that these children have poorly articulated conceptions of the site or context in which their dwelling is situated. To speak analogically, the nests/dwellings relationships shown by the youngest group of children seem to hover in an undifferentiated medium, perhaps water or air. Their solutions are not rooted within a particular context.

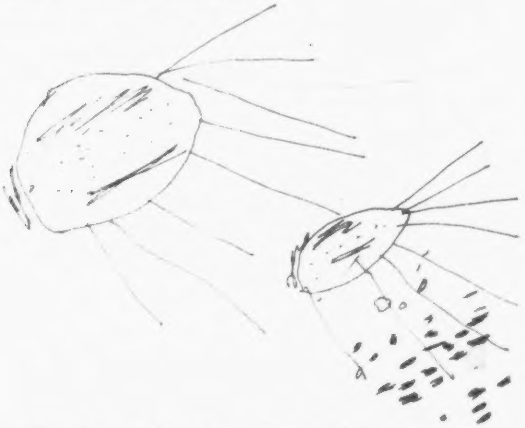
b. Strategies of Form

Built Form or Human Structures as Contrasted With the Use of Naturally Occurring Structures and Elements of the Natural Landscape.



No. 1. Elliot's Representation of the Nest, (Center form bounded by line), Anteater eater (upper left), Pelican (middle left above nest), baby alligator (right of penguin), and anteater (only the long tongue is visible at far right) whose tongue pierces the next. Form: Assim-Passive. Undifferentiated internal structure of nest. Eggs insidenes with leaves "that bite you". Site: undifferentiated. Predators, in order of succession: (1) anteater, (2) half-spider/half-human "anteatereater", (3) spider (spindley shape, lower right), (4) cobra (not visible, lower right).

Neither dimension of the dichotomy stated above is appropriate in describing the characteristics of the forms of the younger children's alligator dwellings, except in a negative sense. That is, there is a marked absence of both natural and human structural elements of form in these drawings. Instead of these dimensions we have to rely on other, more appropriate terms of analysis.



No. 2. world view: The predators are all manner of beasts and insects that bear little relation to actual predator/alligator relationships.

The forms depicted by the youngest children were characterized by (1) symmetry of solution (2) depiction from a plan view (3) schematic or diagrammatic representations.

Most of the representations of dwellings can be described as a circle (the boundary of the next, environment outside, eggs and mother alligator inside) that contains a number of smaller spheres or ovoid shapes. It even is possible in a few cases to divide the dwelling into two equal parts, each containing a roughly equal number of eggs, by a line that bisects the nest form.

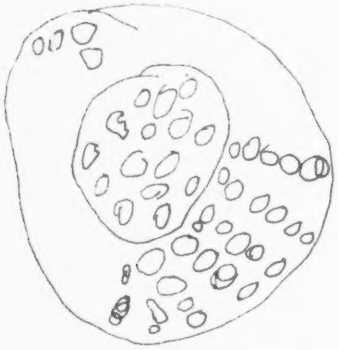
The representations are from above, as if in plan view. There is little or no indication of the three dimensional structure of the nest/dwelling. (See illustrations 3 through 5 and contrast these with the drawings of the older children, 10 through 13.)

Associated with the symmetrical arrangement and view of these representations is their simple schematic nature. There are few textural features of the nest materials represented. For instance, a simple line suffices to indicate (1) the boundary of the nest with its environment and (2) the actual nest. That is, the nest is reduced to a single line that bounds the egg forms.

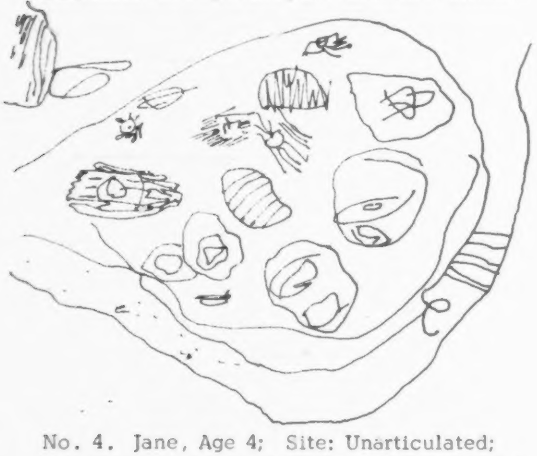
The sole strategy of form used by the younger children is a design strategy we have characterized as assimilative-passive. The assimilative-passive strategy is defined as an acceptance and use of the nesting pattern without any alteration of the details of internal nest/egg arrangement and without altering the relationship of the nest to its site. The term assimilative is used in the sense that this strategy of design represents an assimilation of the information (as a solution) given in the Disney film. It is characterized as passive because there are no active alterations or restructurings, internal or external on the part of the child, it is a passive acceptance of the solution shown in the movie. One of the marked characteristics of the style of representation is the use of curvilinear lines. In only two drawings of this group were straight lines used; and these straight lines, significantly, introduced the concept of human built forms or materials. (See illustration 6, treehouse and circle within squares.)

Kellogg's analysis of the states of children's representations is germane to this discussion.[6] Her categorization of children's representations as diagrams, combines and aggregates is appropriate to describe the character of the younger children's drawings. The representations of the nest can be described as a fusion of diagrams and combines. The reader is invited to contrast these drawings with those of the older children in order to form a clearer conception of the stylistic shifts in representation as a function of age.

c. Environmental Constraints: The Problem of the Skunk and Racoon as Predators.
Parallel with the undifferentiated or diffuce representations of the dwelling/site relationship and the form and structure of the nest-dwelling is the representation of the predators. That is to say, the predators are not shown in great detail, their bodies and appendages are not articulated and differentiated with any of the specificity that the older children employ. But, there is a sense of the term diffuse that is particularly germane to these representations of predators. The predators shown in these representations are not only those that were shown in the Disney movie. Instead a portrayal of skunks and racoons, there is a proliferation of a variety of predators or threats to the safety and security of the eggs, including anteaters, spiders and cobras.



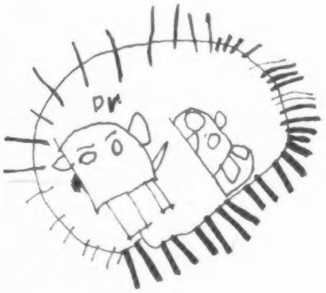
No. 3. Brian, Age 4: Site: Unarticulated. Form: Schematic and diagramatic. Eggs arrayed as ovals within the two lines that bound nest form. Symmetrical arrangement. There seem to be two nests: a smaller circle inscribed within the larger shape. Both contain eggs. Predators: not represented. Child's World View Features: undifferentiated structure: no separate parts within a Whole.



No. 4. Jane, Age 4; Site: Unarticulated; Form: Roughly symmetrical. Schematic mode of representation. Eggs of varying shape within a line that signifies the nest. Predators: not represented; Child's World View: Undifferentiated structure of nest form; however, eggs themselves are differentiated.

For instance, in the case of Elliot, we have a fascinating relationship between two predators (neither of which was shown in the movie) that are pitted against each other (at cross-purposes, if you will, See illustrations 1 & 2.) The primary threat to the eggs is an anteater. It doesn't seem to be a contradiction for Elliot, that an anteater (eater of ants) has become an egg eater. But the anteater is confronted with his own predator, the indomitable "anteater-eater" shown above. Elliot explained to us that the anteatereater eats the anteater that eats the alligator eggs." (Perhaps Elliot has a conception of ecosystems, or food chains with relationships of dependence and succession?)

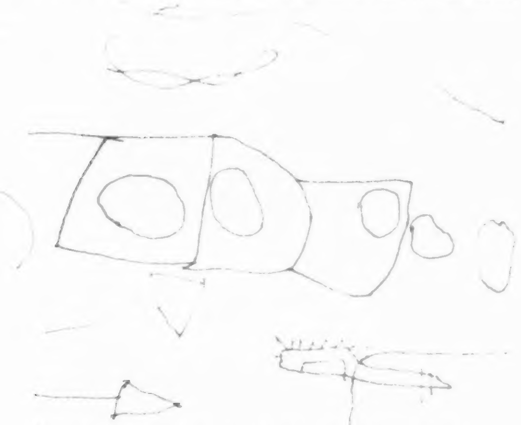
In another drawing, produced by Francis, the predator is an egg eating spider that attacks the alligator eggs situated in a treehouse. In Francis' drawing there is, in addition to the egg eating spider, a predator, a predator called the "eggeater", which, as its name indicates so well, devours the eggs.



No. 5. David, Age 4: Site: Not represented, unarticulated. The form seems to hover in space, perhaps air, water or some other homogenous medium. Form: Symmetrical, spherical nest with alligator (right figure) and David himself (left figure?) within nest. The nest seems to have cillia-like structures on its edges; perhaps a means of mobility or, more probably, a means of defense. Predators: not represented. Child's View: Representation of David within nest.

What is fascinating in all these predator representations is that there are animals and insects shown whose life patterns have little or no relationship to alligators and alligator eggs. The predators are indeed specific (i.e. spiders, anteaters, cobras) but their relationships to the alligator clearly does not conform to the logic of natural relationships given in real ecosystem. It goes without saying that these predators were not shown in the Disney film.

We would maintain that the children's conception of predators, and particularly the relationship between the predators and the alligator eggs is diffuse, undifferentiated or non-articulated. The conception of predator, as a particular animal, whose unique life patterns bear a specific and often inimical relationship to those of another animal is hardly demonstrated in these drawings. The predator in these drawings are cognised as threats to the alligator eggs; but the predator representations fail to show in what specific ways the predators constitute a threat. Francis' drawing and identification of a predator as "the egg-eater demonstrates this partial understanding of the concept of predator. She has grasped the general features of "predatoriness" (indeed her predator is a universal predator, it is "the eggeater") without grasping those particulars that constitute an "alligator-egg" predator.



No. 6. Arlo, Age 4: Site: Unarticulated. Form: Fusion of built form, indicated by roughly square shapes bounding spherical egg forms, and the more typical nest diagram (only a portion of the boundary of the total nest form is visible-the line crossing photo from upper left to middle right. Predators: Unarticulated. Alternate defense is the pointed leaves (left hand, lower corner).

The connection between the lack of predator specificity and the lack of site/dwelling or dwelling/structure articulation is clear enough. How can the child set to work designing a dwelling place that is safe from particular predators if his conception of the predator lacks specificity and definition? In a word, the particular habits, anatomical structure and living patterns of skunk and racoon constituted the major constraints or limit set upon the design of the alligator home. If the particular characteristics of the predators are not unique, then the choice of a site or structure as a design strategy in relation to the predators is not necessitated.

d. The Child's World View

A number of these early developmental features of cognition and representation were touched upon in the above discussion, namely the symmetrical, circular and diagrammatic nature of the dwelling representations, and the lack of differentiation and articulation between dimensions of the problem (i.e. the articulation between site and dwelling, structure/form of dwelling and predator and predator/site relationship). Each one of the members of these diadic relationships considered as a unit, lacked differentiation and specificity. These features of the representations (and their conceptual counterparts) fit lowfully into Werner's account of development in which development proceeds according to an increasing differentiation and hierarchic integration.

There are additional features of an early developmental level of cognition and representation that ought to be mentioned, namely, examples of syncretic, animistic and egocentric, or pre-operational thought.

Elliot's representation of the predator as a "half-spider", half-human creature, indicates the syncretic character of his notion of predators. His predator consists of a fusion of two categories of living creatures; spider-forms and human characteristics are united in his representation to form a composite creature.

Another curious fusion of characteristics that might well be described as an example syncretic thought is Arlo's dual defense of the eggs. (See illustration 6.) Arlo has surrounded his eggs with individual squares that are presumably some kind of built housing to protect the eggs. In addition to this attempt at a built or structural strategy of defense, Arlo has also provided a kind of magical defense by means of sharp, spear-pointed leaves. Whether these leaves are endowed with consciousness of some sort was hard to determine. But Arlo has clearly alternated between a built strategy and a kind of natural strategy that employs strangely endowed plants.

Animism, or the endowment of inert and/or living components of the environment with the features of consciousness, particularly intention, is a typical characteristic of these drawings. Not only did Elliot provide an "anteatereater" to deal with this anteater predator, but he also told me that leaves protect the eggs from the anteater. I asked him how did they (the leaves) do this. He responded by saying "Oh, when the anteater comes to the nest, the leaves bite him!"

Finally, there are characteristics of these representations that we have labelled egocen tric and pre-operational. In a few of the drawings the children have represented themselves, either inside the nest, next to the eggs, or even containing the nest. In David's representation of the nest he included (see illustration 1) a "D", presumably signifying himself, alongside of the eggs.

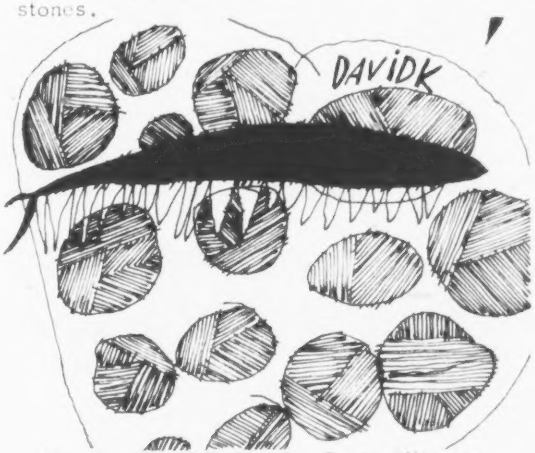
Description and Analysis of the Older Children's Representations

a. Strategies of Site Selection.
In marked contrast with the drawings of this group show a consciousness and articulation of the concept of site. Variation of site was used as a major strategy in designing a dwelling place that was safe from the predators.

Assimilative-passive. This strategy involved the simple depiction of the alligator, nest and eggs in the relationships shown in the film. That is, a nest with eggs, covered with some material, on the ground level. No essential modification of the internal structure of the nest nor any novel use of the site as a means of protection is displayed. Although strategies of this type were not frequently used, the example of David K's dwelling illustrates the case. (See illustrations 7, 8 and 9). In these drawings the mother alligator sits on her symmetrical nest containing many red eggs. Another example of this strategy is Lori's painterly rendering of mother alligator, eggs and nest.

Assimilative-active. This strategy involved an acceptance of the nest/ground level relationship shown in the film in conjunction with significant alterations in the internal structure of the nest or eggs. The site remains constant while the characteristics of the nest/egg system are changed.

A fascinating example of this strategy is Larry's egg restructuring solution. While the nest and site remain essentially the same as shown in the film, the characteristics of the eggs themselves are altered to afford protection from predators. In his drawing, the turtle shaped skunk is in proximity to the eggs. In fact, according to Larry, the skunk is sniffing the eggs. But the eggs look and smell like stones.



No. 7. David K; Age 6. Green Alligator with red eggs in nest. Site: Assimilative passive. Form: schematic; typical nest solution. But more pictorial and less linear than drawings shown in younger group. "The alligator guards the eggs".

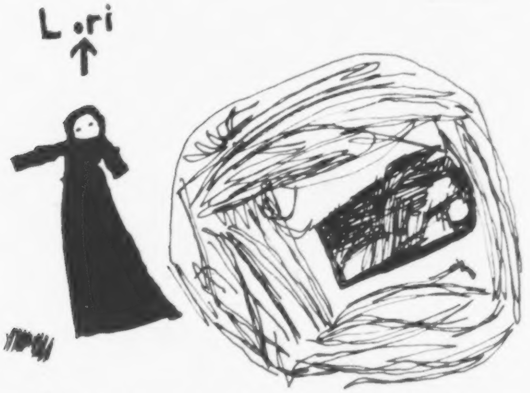
This ingenious method of protection uses the ovular shape of the eggs as a starting point in a strategy of camouflage by imitation of inert forms, rocks and stones.

Site-active Strategies.
By far the most numerous and fascinating strategies of protection were those designs that altered the site-dwelling relationship in order to insure protection from the predators. The site or context of the dwelling was altered in order to solve the problem of protection.

These site-strategies can be grouped into three sub-classes, each of which is based upon a different zone of the environment: (a) above ground, (b) on or under the water of the swamp (c) below ground level.

An example of an above ground strategy is Megan's representation, in which the alligator dwellings are located in a tree.

Susan's representation is a clear example of strategies on or under the water. She has located the alligator nest and mother on a log, floating in the swamp. When asked how this gave protection from the predators, she responded, "because skunks and racoons can't swim." Wally F's creation of an underground home (see illustration 10). complete the special entrance, presents the third zone of the environment that was utilized in attempting to create a safe alligator dwelling. The dwelling is represented as if in section view.

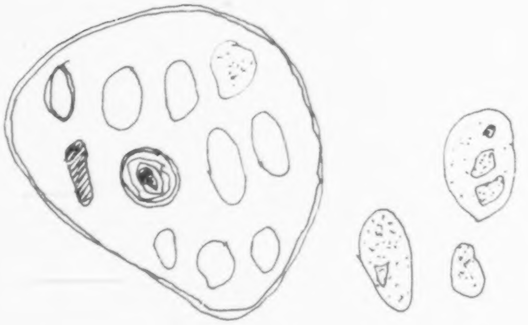


No. 8. Lori, Age 6, Site: Assimilative-passive. Form: Nest/egg relationship as shown in film. Style: pictorial. Child's view: Lori represented in the picture, alongside of the nest.

Clearly, in all these cases of site strategy, and especially those site-active solutions, the differentiation, articulation and use of context forms a marked contrast to the lack of a contextual dimension in the younger children's drawings.

b. Strategies of Form.
Perhaps the most striking features of these drawings is the presence of structures that represent human habitations (indeed a variety of house forms). These structures are alternately made of elements and materials that are man-made (i.e. boards, bricks, etc.) or naturally occurring materials (i.e. straw). In any case, the predominance of structures or house forms in an architectonic sense, forms a marked contrast to the undifferentiated, roughly spherical shapes that characterized the nest/dwelling forms of the four year olds.

Further, these dwelling forms as shown in elevation or cross-sectional views rather than plan views. There are certain drawings that have a suggestion of tri-dimensionality about them. While the dwelling forms have a marked symmetry to their design there is an increasing differentiation of parts within the whole that constitutes each house. In a word, there is an increased differentiation of parts within a whole. For instance, in the case of Wally's underground shelter (illustration 10) there is a particular form that erupts from the surface of the circular, underground home. This form is an entrance leading from the surface of the ground into the shelter/dwelling below.

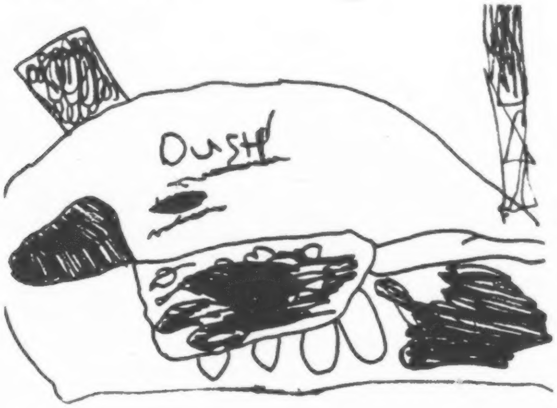


No. 9. Steven, Age 6; Site: Unarticulated. Form: Schematic. This simple, diagrammatic solution is not typical of the representations of the other older children.

Concommitant with the appearance of built forms is the use of straight as well as curvilinear lines to represent these forms. In fact, these straight lines seem to be a cue that indicates the presence of a human shelter. Again Kellogg's analysis proves useful. The drawings of shelters in this older group could be characterized as "early pictorial." There is a fusion of the earlier symmetrical and spherical dwelling diagrams and a more "representative" or conventionalized form of drawing. It is almost as if the house forms budded of the circular forms used by the younger children; they are undergoing a differentiation and articulation. Part and part systems are beginning to be differentiated and articulated within a whole. Here are some particular instances of human structures or human dwelling forms and materials: (See illustrations 11, 12, 13) (a) Sandra's house which is made of "red rock", roughly igloo shaped and located on the ground (b)

Marie's brick house, also igloo shaped and "made by the alligator", (c) Claire's igloo shaped brown straw house, located on the ground. Each one of these dwellings has either portals, windows or an entrance. We are privileged with a "view inside" as it were. Internal structure, skin and site are represented, either in part, or simultaneously, in the same drawing.

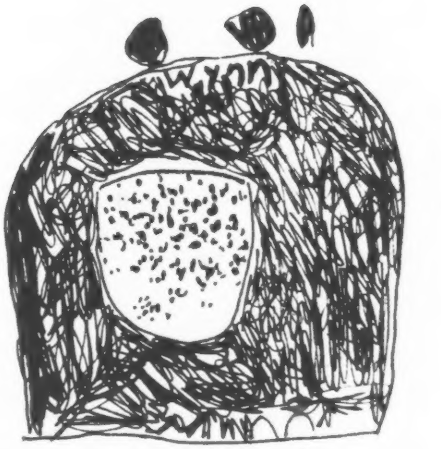
One of the creators of these human type structures had an interesting comment to make about the dimensions of his "big wood house". Joey had told us his house was big "so she (the mother alligator) can have lots of room." He seems to have concern for the "creature needs" for ample space.



No. 10. Wally F, Jr. Age 6; Site: Site-Active. An underground dwelling that "the alligator digs with his claws". Chimney-like appurtenance is the "entrance" the alligator uses to get into his house below the surface of the ground. Notice how the eggs were originally located in alligators belly, were subsequently erased and then located near the tail, far right.

Wally's example of a use of natural features of the environment provides an interesting fusion of built and natural features. While his underground house had "human" features to it (a special entrance that is geometrical and straight sided), he told us that the "alligator digs it (the grotto or underground shelter) with his claws". That is to say, the walls are made of earth instead of wood or bricks. This dwelling is also one of many examples of troglodyte type dwellings.

Interesting juxtaposition of human house form



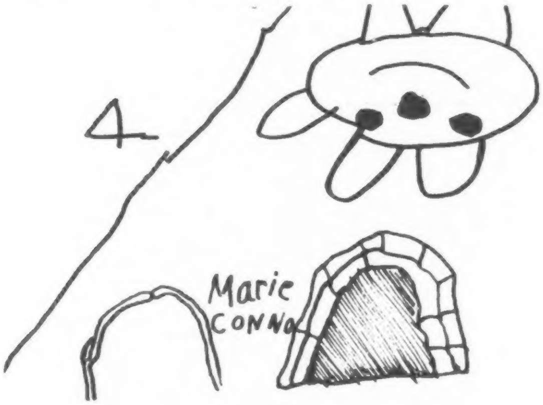
No. 11. Sandra D. Age 6. Built form. "Made of red brick". "The mama and papa go out into the woods and get the bricks." Either shown in elevation or section: the eggs are in center of shelter (the dots).

and alligator site is shown on Beth's drawing in which a house is submerged below the water line. The baby alligator can be seen in the "upstairs" window. Beth told us that she "built in the water to let them swim". Not only are sites chosen for the protection they afford from predators, but also (in this case, at least) because the child has been able to cognize or, perhaps, empathize with a particularly "alligator-like" environmental need.

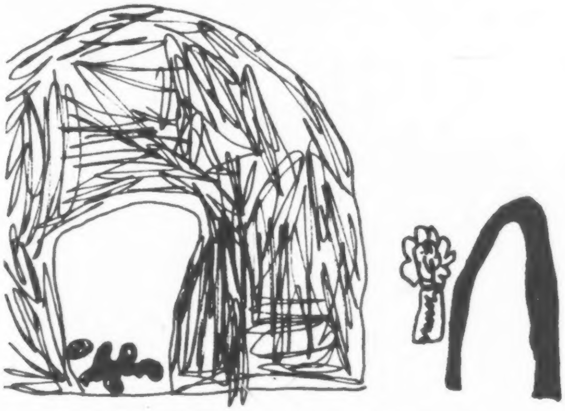
c. Dealing with Environmental Constraints

In contrast to the representation of the younger children the predators are limited to the skunk and racoon in these drawings. Further, the bodies of the skunk and racoon, as well as the alligator, are drawn with a great deal of specificity. The distinctive features of the animals, the skunk's bush tail, for instance, are shown with much greater clarity and definition.

When we enter into the relationship between the children's attention and cognizance of the predators patterns and motoric capacities of the predators in particular, and the site or structure of the alligator dwelling, the data is more ambiguous. That is, in some cases the child has designed or located the dwelling in such a way as to prevent the predators' entrance or approach. A good example of this "reality-oriented" solution is Susan's alligator nest on a log. As stated previously, when asked how her solution maintained the safety of the eggs, she responded, "because skunks and racoons can't swim". Clearly, she has cognized the motoric capabilities of the predators and situated her house with this fact in mind.



No. 12. Marie, 6. "Red Brick House". Site: Unarticulated. Form: Human type shelter. Alligator shown on "floor". Seemingly in section, showing articulation of constituent "bricks".



No. 13. Claire, Q. Age 6. "Big brown straw house". Site: Unarticulated. Form: Human-type shelter. Predators: Not represented. Anthropomorphic, egocentric representation. Alligator shown in entrance, also (upper left of mother alligator) the mass of eggs.

But Susan's design solution and the knowledge it implied was far from characteristic of the children's solutions. In most cases, even when the site was altered, the strategy employed did not take into account the particular patterns of the predators. As an example of this kind of non-functional strategy, the reader is referred to Megan's drawing of the alligator home in the trees. Despite her use of the site as a design variable, she was not able to deal with the facts that (a) racoons can climb trees and (b) alligators cannot.

Despite the fact that many of these solutions are dys-functional in relation to the characteristics of the predators, we should point out two emerging features of the older children's representations: (1) the predators are specifically depicted as the skunk and racoon and (2) many of the site-active solutions as well as the assimilative-passive designs are "successful" in dealing with the predators. The mere presence of either strategy, the altering of the context of the dwelling or the internal structural characteristics of dwelling form, represents an increasing attention to significant dimensions of a design problem.

d. Features of Early Development Levels of Cognition and Representation.

The most characteristically "childlike" features of these designs is their "egocentricity". That is, all of the numerous human-type structures were built from the perspective of the children's (as human beings) capability. Obviously alligators are not capable of making bricks nor of constructing brick shelters. The same feature, egocentricity of perspective, is applicable to the tree-solution, the red-rock house and the "big brown straw house". The children designed houses, occasionally with domes, roofs, doors, and entrances that only a human being could have devised.

There are also fusions of assumptions about human designs and alligator "needs" in the representations that might be characterized as syncretic. For instance, the human type structure (with an "upstairs" for the baby alligators) that is submerged in the swamp in order "to let the baby alligators swim" is a fusion of two perspectives, as it were, human capabilities and alligator "needs" or "preferences". Another fusion of this type is the underground shelter that is dug by the alligator (with his "claws") but has a markedly geometrical and "built" aspect to its entrance.

One of the most ingenious "site-active" solutions has not been described. This is the case of Shawn's solution who proposed that the nest be located on the mother alligator's tail. This unique solution solved the problem of safety for the eggs, but involved, again, assumptions (egocentric) about the motor capabilities of the mother alligator. Actually, and this is a feature common to many of the drawings, the scene shown portrays a sequence of events in time. The first sequence shows the eggs below the alligator in a traditional (i.e. assimilative-passive solution) manner. The next event shows the eggs in a nest on the mother alligator's tail, with the mother's head turned backward toward the nest. The skunk is successfully warded off. Shawn narrated the sequence as follows: "The mother alligator puts the eggs in the nest. (1st solution) But the racoon comes and eats them up. So she puts them (the eggs) on her tail. The skunk is scared away". The portrayal of a story, or events in a sequence is similar to the techniques of medieval painters who portrayed a sequence of events in time within the same frame. (Perhaps the narrative-representational technique of the children and the conventions of representations in Medieval share some common features.)

As a last example of a fusion of both accurate, differentiated perceptions and concepts as well as egocentric operations we site the case of Megan's tree-solution. Here is a clear example of egocentricity: alligators neither climb trees nor can they build human type shelters on any terrain. At the same time, however, Megan shows a clear cognizance of one of the alligators most striking dimensions: its gaping mouth. When I asked her how the alligator would carry up the "boards" (her word) for its house, she replied, "He carries them in his beak." This reply contrasts sharply with the younger children's diffuse portrayal of alligators. While her "solution" is marked by contradictions of the wildest sort, she has demonstrated a rudimentary differentiation of the motor capabilities of an alligator. After all, she could have replied, "he carries them (the boards) in his hands."

There are certain mythical or archetypal dimensions to the children's site-solutions. Their choice of below-surface, underground structures, and above ground (celestial) structures resonates with the tones of mythical topologies.[9,10] It is almost as if they have used the archetypes of "underworlds" and "heavens" in seeking a site-solution for the alligator dwelling. Even the conical or rounded shapes of their human-type dwellings are reminiscent of the most rudimentary and ancient of human house-forms, the hut. Speculations beyond this point as to the archaic or archetypal aspect of their designs are not appropriate here. Suffice it to say that these dimensions of a child's representation of the alligator dwellings are worthy of comment and further investigation.

A Comparison of Both Groups

In three of the four categories of analyses, site, form and environmental constraints, there were clear differences between the younger and older children's representations. In relation to these three dimensions of analysis the representations of the younger groups lacked specificity, differentiation of parts with a complex whole, and articulation of relations between these parts to form a "functional whole".

In both groups of children's representations, we found characteristics of early developmental levels of thought and representation, including syncretic fusions of distinct entities, magical or animistic though, egocentric use of "human" assumptions and capabilities in design solutions and, lastly, the suggestion of archetypal images in the representations.

The Child as a Model for the Designer.

One Perspective.

> "You all know what happens after a snowstorm? The child takes over - he is Lord of the City. You see him darting in every direction collecting snow off frozen automobiles. A great trick of the skies, this, a temporary correction for the benefit of the neglected child..."
>
> Aldo Van Eyck, Team 10 Primer

Children exhibit a conglomeration of features on many levels of functioning, behavioral, perceptual and cognitive, that we feel are desirable to cultivate in the adult designer. These characteristics might be termed, (1) cognitive flexibility, (b) a sense of theatre, role-playing and improvisation, the ability to "become" another person, (3) awareness and sensitivity to elemental sensory qualities of the environment.

Children are capable of investment in a scene or context in a manner that might be termed "immersion". They are able to grasp the drama of a situation (i.e. the situation of the mother alligator and the protection of the babies) in an immediate and vivid way. Children have a way of "becoming" or entering into a situation that is immediate and felt (on an affective as well as cognitive level). They have a sense of improvisation or "theatrical-enactment" about a situation or space that gives them great latitude and flexibility. The child is capable of responding to an object or space in a variety of modes; in fact, the child is capable of entertaining a multiplicity of definition of the objects or spaces, that surround him. This flexibility stands in marked contrast to what might be termed the "typical" adult mode of response to spaces and the environment at large. The child's flexibility of response manifests itself on a number of levels including the behavioral (construed in the sense of overt motor acts), perceptual and cognitive. This feature of a child's relation to the world of spaces and environments can be described in a number ways - a mobility of frames of reference, a mobility of attitude and orientation, a fluidity of response.

The characteristics of a child's response to spaces are operant precisely because the child's framework or "view of the world" is not yet stabilized or delimited in the way an "adult" world-view is. Piaget's work testifies to the fact that the young child has (1) not assimilated relations that "govern" the facts of the real world and (2) not accommodated his cognitive "structures" or schemata to the information given to him. The child has yet to develeop those operational features of cognitive functioning that are the basis of a stable frame of reference that is alternately described as "objective", "realistic" and "reality oriented". While this acquisition of a stable set of schemata is, indeed, necessary for "objective, technical thought", it has a double edged significance. While orienting or fixing the world about the child in a stable and useful frame of reference, the very rigidity of this framework mitigates the use of varied, multiple perspectives. It is flexibility and mobility of perspectives that seems desirable to encourage and nurture in the student of design.

We must make clear, however, that we are not maintaining that the designer become, in some mysterious fashion, a child. We are not remanticizing the child's modes of functioning in the way that nineteenth century anthropologists romanticized and idealized the societies and mentality of "primitive" peoples. The "causes" or dynamics operant in a child's flexibility (behavioral, perceptual and cognitive) and rooted in a stage of development that is necessarily relinquished as the child matures. Those features of an adult orientation, characterized as "operational", "reality-oriented" or stability of frame of reference, must form part and parcel of the adult designer's cognitive equipment. The egocentricity and lack of operational thinking that characterized a child's approach to design form obvious limitations to the child as designer model.

What we are maintaining, on the other hand, is that only certain features of a child's mode-of-being form useful analogues to the kinds of functioning that should be promoted in designers. Perhaps the kinds of pedagogic techniques that would produce such a lability or flexibility of perspectives (in all levels) are not remotely related to the processes that underlie such characteristics in a child. The techniques used to awaken or re-vitalize these characteristics in adults may or may not be of the same structure as those used in the children's Learning Experience. The design of educational methods that would awaken these sources of flexibility in adults is a field that lies open to investigation. We merely have suggested that such an awakening is of critical importance.

In the last section of the original working paper we suggest two levels of analysis, the encounter and the dialogue, which may be fruitful in attempting to construct pedagogic techniques that enable a designer to enter into the human diversions of design problems with more empathy and immediacy. Briefly, the encounter signifies the level of the encounter between body senses and the world of designed space while the dialogue includes the way in which cultural systems (i.e. belief, values, systems of classification, behavior rituals) interact, which shape our perception of our behavior within the built world. It is maintained that a heightened awareness of both these levels of interaction between men and space would increase our capacity to enter into the world of the persons, for whome we are designing. These notions are developed in much greater detail in the original paper.

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29: RELATING RESEARCH TO PRACTICE

DESIGNING TO REINFORCE THE MENTAL IMAGE, AN INFANT LEARNING ENVIRONMENT

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Abstract

The reasoning and design for an actual physical setting organized to have a deliberate reinforcing effect on the mental development of infants is presented as a demonstration of the possibilities of design based on knowledge of cognitive development and to illustrate the theoretical potential of a lingustically conceived model of cognitive development keyed to classes of visual form.

Introduction

If architects are to design so as to confirm or transform the cognitive representations by which people know the environment it is necessary that they understand how these representations are acquired and how the environment might be designed to more directly conform to and influence such representations. This knowledge implies a theoretical comprehension, a mental schematization, of cognitive development and function extending to a linguistic conception of the environment itself.

It is the purpose of this brief paper to sketch the process of mental development in children as evidenced in the psychological literature, (particularly that of Piaget) (1) to present the design of an environment intended to complement and foster this development, (2) and to put forward a normative model for environmental information that is based on cognitive development and function and which seems to have linguistic utility as a framework for relating the physical and cognitive worlds.

Background

There is a great deal of information, most of it only now coming into focus, regarding the process of mental development by which the infant builds the cognitive foundations for the environmental images of later life. (3) Werner, Piaget and Bruner have established that mental development builds from direct sensorimotor activity in concrete physical settings to the symbolic coding and cognitive manipulation of abstract thought. Werner has recognized three successive levels of development and termed them sensorimotor, perceptual and contemplative (4) while Bruner has noted that children pass successively through three modes of representing the environment which he calls enactive (images recalled as actions) the iconic (images recalled in terms of their formal and physical properties) and the symbolic (images recalled through labels, cues and associations) (5).

Cognitive Development

Piaget has provided a much more detailed description of this ontogenetic progression. He tells us that mental development begins with functional reflex actions such as sucking, touching, etc., in which the child mentally accomodates a single action, a group of sensations as an isolated event. During the first months of life, as long as assimilations (of experience into the mind) remain central to the organic activity of the subject the universe presents neither permanent objects, nor objective space nor time interconnecting such events as such, nor causality external to the personal actions. (6) The child lives in a world of his own fragmented actions which constitute his means of exploring his world and of apprehending the percepts which it presents. His original "purposeful mobility" (7) is organically motivated yet responsive to sensory stimuli. This sensorimotor activity soon becomes schematized as a process having continuity as the child acquires the ability to follow or rediscover by means of coherent movements the perceptual images associated with his direct sense experience.

With the subsequent coordination of sight and movement growing from this ability he then learns to coordinate the different previously constituted practical spaces into a single system and to form objective groups in the field of perception. The infant then becomes able to intercoordinate these groups and acquires the ability to conceptualize the world beyond the field of immediate perception to a limited degree. He remains limited in that conceptualization is tied to the immediate objects of his perception and extends causally from them.

In the final stage of this initial sensorimotor period for the "acquisition of perceptual invariants" reciprocal relations are established among and between bodies in motion and at rest and the child is able to direct his search to combine schemata mentally without having to directly perceive them. With this he acquires his sense of himself as an object and as an actor in the world. As Piaget says the basic organization of reality has occured" to the extent that the self is freed from itself by finding itself and so assigns itself a place as a thing among things an event among events." The infants sensorimotor intelligence has elaborated his understanding of the world sufficiently to make sensorimotor language and representation possible (and) the universe is at once substantial and spatial causal and temporal." He has entered the realm of symbolic communication and abstract thought. (8)

The Design Program

This description of mental development in which each stage is integrated in succeeding stages has provided the program for the design of an infant learning environment. In the environment the new born infant is provided with a crib-place containing well-formed and particular sensations each in its own location and each possessing a distinct and related activity pattern or movement to attract and hold attention. In this particular design these stimulus elements have the following distinctive forms: small soft holes with bottoms that pulse in and out; a curving line of varying amplitude, a vertical flat surface subject to rotation, horizontal surfaces or areas having distinct tactile qualities or a bead-bar having groupable rather than intermixed colors, a vertical element composed of elements designed to be lifted, and a particular opening or portal at which an adult normally appears to attend or remove the child. It will become apparent that these stimulus elements are not arbitrary but prefigure at the level of initial perceptions the forms which in the larger infant learning environment contain the child.

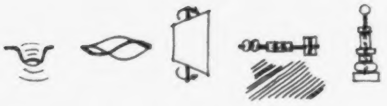

Figure 1

The fixed location of these elements is intended to reinforce the child's attempts to establish the habitual perceptual images of the second phase of mental development by confirming his expectancy of perception in a given place, and by reinforcing his prior sensations. By maximizing the differences between the sense elements and holding them to a number within the organisms capacity for short term memory (within 7 ± 2 distinctions) (9) the intent is to clarify and smooth their perception. These fixed locations in this design also reflects the empirical evidence which suggests that the child's first perceptions are schematized in terms of the movement of the body and its componant parts. (10) The design of the crib-place further acknowledges the action focussed, egocentric, and organically motivated response of the infant to individual stimuli.

The second stage of development, characterized by the continuity of recognition (constrained by the attention span and complexity of the motivating stimuli and tending toward the construction of a coherent representation integrating the images of the perceptual events of the first stage) is reinforced by scaling the nesting place to the limited sensorimotor domain of the infant, bounding it and containing the visual field to provide a stable background against which activity patterns and sense elements may be holistically perceived. This containment helps the infant to concentrate on the limited number of activity centers and locate them in space relative to himself. It also prefigures the fixed systems of reference which follow the egocentric stage in that once the child has a coherent representation of his nesting place he is in a position to transfer the center, the node, of this organization to some fixed reference object or landmark. It is important to note that this partially enclosed environment is only one of many that the infant is experiencing (car, carriage, house, etc.) but it is the one scaled to and centered on him and easiest for him to physically explore, and thus comprehend.

As the infant mentally assimilates the organization of this partially closed environment its design encourages him to discover the objects near at hand but partially concealed by its boundary. Thus, the environment fosters the formation of the inside-outside schemata and reinforces the child in his now complementary ability to crawl and explore. The bounded domain which the "nest" represents when perceived either from the inside or the outside, helps to distinguish its object character for the child.

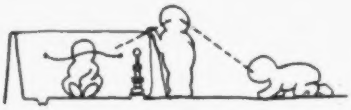

Figure 2

He is either inside the domain and identified with it or outside and therefore related to it. The domocentric or home based image which older children typically manifest as the basis of their first fixed reference system is naturally reinforced by this experience. (11)

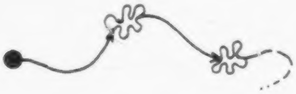

Figure 3

The child's own nest becomes the node or place in the path or route representation which the infant subsequently develops. (12) The learning environment surrounding the node-cave of the child is composed of other distinct form-places which he can visit and learn in the manner of his original nesting place. Thus, his universe is enlarged and his sense of himself as an actor in a stable world containing other actors like himself is reinforced.

Fully locomotive, at around 18 months and possessing words and representations of objects in the world, the infant, still within the sensorimotor egocentric level of development, enters the realm of symbolic meaning and communication. This symbolic capacity is reinforced in the design of the environment by reintroducing the forms of the initial sense elements of the crib-place at a new and larger scale-that of the extended infant learning landscape itself. Indeed, the original sense elements are now revealed to be interpretations of the highly imageable classes of form which Kevin Lynch has identified in the recalled images of a significant number of residents in Boston, Los Angeles and Jersey City. (Three notably different urban environments.) He has suggested that the five classes of elements by which people form their image of these cities were: Nodes, points or intensive foci which people may come to, enter and leave; paths or channels of movement; edges or boundaries which break or contain the continuity of experience; districts, domains or areas which have a recognizable identity, character or form; and landmarks or point references which are external to the observer and are singled out for purposes of identification structuring or orientation (13).

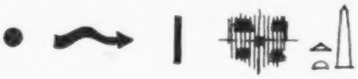

Figure 4

It is suggested that not only do these elements represent important primitive classes of a symbolic visual language or code but that the sequence of their acquisition and integration is as given above, i.e.; first the egocentered node, then the action-continuous path from the egocenter, then the edge, boundary or surface of the object acted upon, succeeded by the area or district as the conceptually bounded abstractly known sensorimotor domain, and the landmark as the fixed reference point to which this objectified image is transferred.

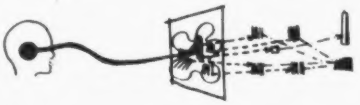

Figure 5

The design of the basic crib-place of the infant learning environment physically reflects and complements this sequence. In the larger infant learning landscape in which these places are located however, each form-place combines the character of the node, the district and and the landmark in order to complement the egocentric sensorimotor stage of the infant. Said otherwise the object character of the nesting places are the dominant features of the landscape just as the initial activity centered sense elements were the prevalent foci within the crib-place. But the larger infant learning landscape is also designed in terms of the symbolic character of the five elemental form classes to manifest the larger world; the buildings and cities into which the children will grow. A description of the learning landscape in which individual nest places are designed as form class elements will present this interpretation.

The Infant Learning Landscape

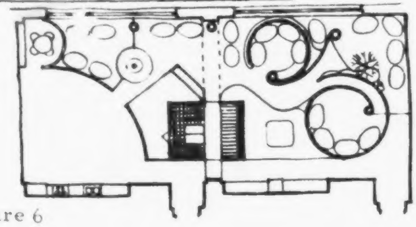

Figure 6

In the top left of the plan of the two conventional school rooms which will contain the landscape is a nature place of organic forms and textures, containing a growing tree, a rock, and water course symbolic of the countryside and recreation. Its oval crib-places range agains the corner walls and a sick bed is sheltered near at hand.

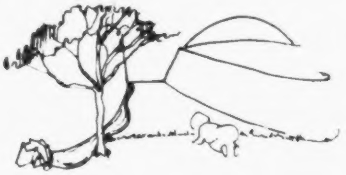

Figure 7

From this place a road rises and then falls to passthe opening to a cave-like space, a quiet domed place of mystery, social intimacy and passiveness which provides a sociopetal reinforcement, symbolic of the council chamber or sacred place.

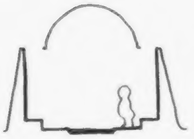

Figure 8

Opposite from the entrance to this cave-like sepulchre the road rises to a high withdrawn space giving a view of the whole (from the top of the mountain as it were). This space provides the infant with a chance to objectify and reinforce his image of the landscape as a whole. From this cluster of relatively organic forms a hard surfaced "road" symbolic of the highway and serving as the actual channel of movement for both toddlers and adults extends toward the places of great socialization and work. Its sometimes curving and eventually straight form reinforces the line of movement it represents while allowing for places along the way to entertain delay and inform the toddler.

Figure 9

One turn in the road leads through a walled hard surfaced enclosure filled with man-made artefacts and toys symbolic of the work place or factory. This geometrically regular, Euclidean space is organized to present increments, intervals of movement, patterns and measures to reinforce the development of abstract, rational, coordinative thought.

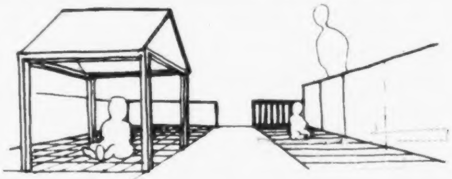

Figure 10

The other fork of the road passes a tower functioning as a totem, a landmark, marking the place of greatest socialization, the eating area. Besides this traditional function as an orienting landmark or reference marker for a place of meeting, the tower symbolizes man's achievement vertically and individuality in a sociofugal form reinforced by the mound on which it stands.

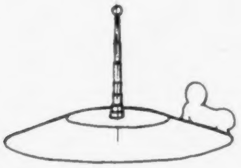

Figure 11

Individual prowess and dramatic physical achievement is reinforced by incorporating ascending musical notes culminating in a bell at the top which an enterprising infant may, with some difficulty, learn to ring. All of the spaces and forms are reinforced by appropriate sounds,textures and colors. For example the cacophonic sounds,strong colors and hard surfaces of the walled work place are differentiated from the melodic sounds, warm colors and varied textures of the nature setting. The form places are also differentiated in the way they reinforce sensorimotor skills.

Significance of the Setting

From a functional point of view each form place (except for the rectilinear walled enclosure) provides an identifiable home for three infants and a caregiver (parent figure). Each is provided with a changing station (a surrogate for the bathroom in a house). Each is sufficiently distinct in its spatial quality to allow a comprehensive range of spatial experiences to facilitate the separation of active and sleeping infants, and to allow for the study of the effects of various spatial settings on the behavior of both infant and caregiver.

Most importantly this infant learning landscape is designed as a visually integrated sensorily organized physical setting, scaled to the infant, and manifesting knowledge of his mental development. It is a physical hypothesis, an experimental setting through which to examine the effect of the environment on the mental development of infancy and to learn more about how the perceptions of infancy come to prefigure and influence those of adult life. It is not as most nurseries and day-care facilities, merely a conventional adult scaled room filled with unintegrated furnishings designed to make child care less demanding of adults and filled with miscellaneous toys designed to serve narrow and uncoordinated learning tasks.

Instead, such an infant learning landscape as is here proposed might fulfill four of the goals desirable in educational day care facilities today: it would invite the infant to extend himself toward greater confidence and competence in the exploration of his surroundings; foster development of a coherent, cognitive model of the larger world; encourage strong social relationships with adults and other children, and for staff, provide surroundings that are content rich as well as functional.

A Theoretical Framework

A linguistic conception, a theory of description, communication and analysis of the environment itself may follow from the empirically supported pattern of cognitive development which has informed this design. This conception, at the level of a form class categorization, recognizes an heirarchical structure in Lynch's five elements of imageability that is progressively more complex and abstractly integrated in a manner keyed to cognitive development.

This system of cognitive destinctions appears to have direct and important relationships to architectural theory, problem solving thought, information handling and even language itself. (14)

It may be simply characterized by the following mapping of the ontogenesis of cognitive development onto Lynch's elements.

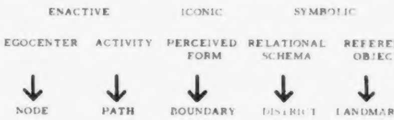

Figure 12

It will be noticed that this scheme manifests the empirically confirmed dimensions of cognitive development ; from concrete to abstract, from fused to differentiated, from egocentrism to perspectivisim, and from immediate change to functional flexibility with stability over time. (15) The mapping onto Lynch's elements implies a similar sequence of development and integration in the use of these elements for structuring the mental images which they manifest. Experimental confirmation of these relationships would have important ranifications with regard to the cognitive organization of perceptions, as well as the theory of man-environment relations.

The scheme offers the rudiments of a theory of architecture in that it lends an operational humanistic interpretation to the archetypal elements of architecture in a manner which integrates the distinctions of classical architectural theory.

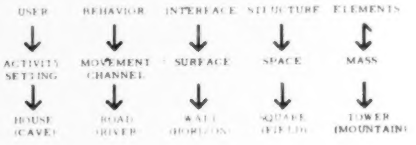

Figure 13

Norberg Schultz has described specialized constructs of space which help us orient and adopt to various aspects of the environment which can be mapped onto the proposed scheme to provide an integrated theory of spatial description keyed to cognitive development. Norberg Schultz notes:

> "We have so far distinguished between five space concepts: the pragmatic space of physical action, the perceptual space of immediate orientation, the existential space which forms man's stable image of his environment, the cognitive space of the physical world and the abstract space of pure logical relations. Pragmatic space integrates man with his natural 'organic' environment, perceptual space is essential to this identity as a person, existential space makes him belong to a social and cultural totality, cognitive space means that he is able to think about space, and logical space, finally, offers the tool to describe the others. The series shows a growing abstraction from pragmatic space at the 'lowest' level to logical space at the top, that is, a growing content of 'information'. Cybernetically, thus, the series is controlled from the top, while its vital energy rises up from the bottom." (16)

A clarification of these concepts consistent with the theory would be pragmatic, functional, existential, logical, and symbolic space.

More generally it is acknowledged that the stages of mental development manifest themselves for all of us in the working through of any process of thinking. (17) An interpretation of the proposed system according to particular roles has been explored in the organization of interdisciplinary teams in group dynamic settings, and in the study of information handling dynamics in actual problem solving with salutory effect. (18) In this interpretation of the distinctions the roles and the types of information associated with them are:

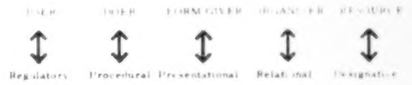

Figure 14

These information types and roles and the relationships implied by the theory have been the basis for the design of comprehensive linguistically conceived, computer oriented information systems to facilitate communication and design. (19)

Conclusion

This brief theoretical outline does no justice to the full implication of the line of reasoning it suggests. Nor does it adequately represent the facility of this comparatively developed model of cognitive development as a normative framework for integrating and structuring large quantities of both empirically validated and philosophically determined information. It has proven to be an epistemological model of real utility to the author and one which offers the advantage of a linguistic flexibility applicable to both the physical environment and the cognitive world which is the individuals prevailing reality.

This outline of a general theory has been sketched here in relationship to the design of an infant learning environment in order to suggest the notion that architects who relate their design to knowledge of cognitive psychology may find themselves involved in a universal linguistic system not founded on historic styles, or geometric combinations but on human experience with, and understanding of, architecture. They will discover a new conceptual foundation for architecture that embraces symbolic content and meaning as well as the traditional notions of form, function and technology or mass surface and space. (20)

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THE HIGHLANDS PROJECT: A UNIVERSITY ACTION/RESEARCH GROUP PLANS A NEW COMMUNITY

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Introduction

Everyone is planning new communities today -- and Rensselaer Polytechnic Institute in Troy, New York is no exception. This university and several of its academic units, however, are in the midst of a "hands on" experience in planning the Highlands Project - a new community on 2,000 acres of undeveloped land in the heart of the Capital District, New York State's fourth largest metropolitan area.

The experience has been an interesting one. It has demonstrated some of the benefits of involving academic institutions in these kinds of projects, just as it has illuminated some of the problems which must be faced in actually pulling it off.

This paper will present many of the details of the project; how it was started, what forces were at work, what set them all in motion, how funding was secured, how the project team organized to do the work, project goals and their implication, results, and some reflections on the process and what came out of it.

The Highlands Project, and Rensselaer's participation in it, is not offered as a model to be followed, but as a case study to be examined for what it can tell others who are considering hands on work in new community development.

To Start With: A Piece of Land

In the late 1940's, it appeared that space for expansion of Rensselaer Polytechnic Institute's in-town campus in Troy, New York would be limited, and at that time, suburban sites for new college campuses appeared to be attractive. RPI found such a site in the Town of North Greenbush, south of the city, but well located within the 3,000 square mile Capital District region of New York State. (Figure 1)

During the 1950's, land adjacent to the existing campus became available, and plans to move were reevaluated. Since that time there have been a number of proposals for disposing of the land resource: to build a junior college there, to locate a research park there, and to sell the land for more speculative developments.

In the mid 1960's, Rensselaer began to look at the resource as an investment from which support for its academic programs could be drawn. Through gifts and some purchases, the parcel was "rounded out" to include about 1,260 acres.

The site was, and is, essentially undeveloped. With nearly 1,000 acres of adjoining land in very much the same condition, a major undeveloped land resource of over 2,000 acres lies in the heart of the Capital District.

There have been a number of forces which have worked to withold the land from the kind of extensive development which has characterized some other locations in this region over the past decade:

- Located on the east side of the Hudson River, it has traditionally been inaccessible, unless one wants to cross old bridges and travel through congested urban centers to get there.
- In the 1950's and 1960's, state government and other enterprises shifted from the city of Albany, (the region's largest and most important city which lies just across the river from the Highlands). They generally moved west and north, opening up areas on the other side of the region for development. The region's early expressways were built in this area, thus reinforcing the westward move.
- The Highlands area itself did not fare well in the glacial years. An unstable river escarpment runs through the site (figure 2), and the uplands area, which is most attractive for development, is on clay soils which present sewer problems if developed with on-site disposal systems.

In recent years, though, each of these forces is being turned around. The regional highway network now connects east and west sides of the river with four new bridges, and provides access without travelling through center cities. The sprawling $1.5 billion South Mall governmental complex being in the city of Albany will shift the job focus back eastward. And plans for a subregional sewer system, with a treatment plant on part of the Highlands site, are in their finalization stages.

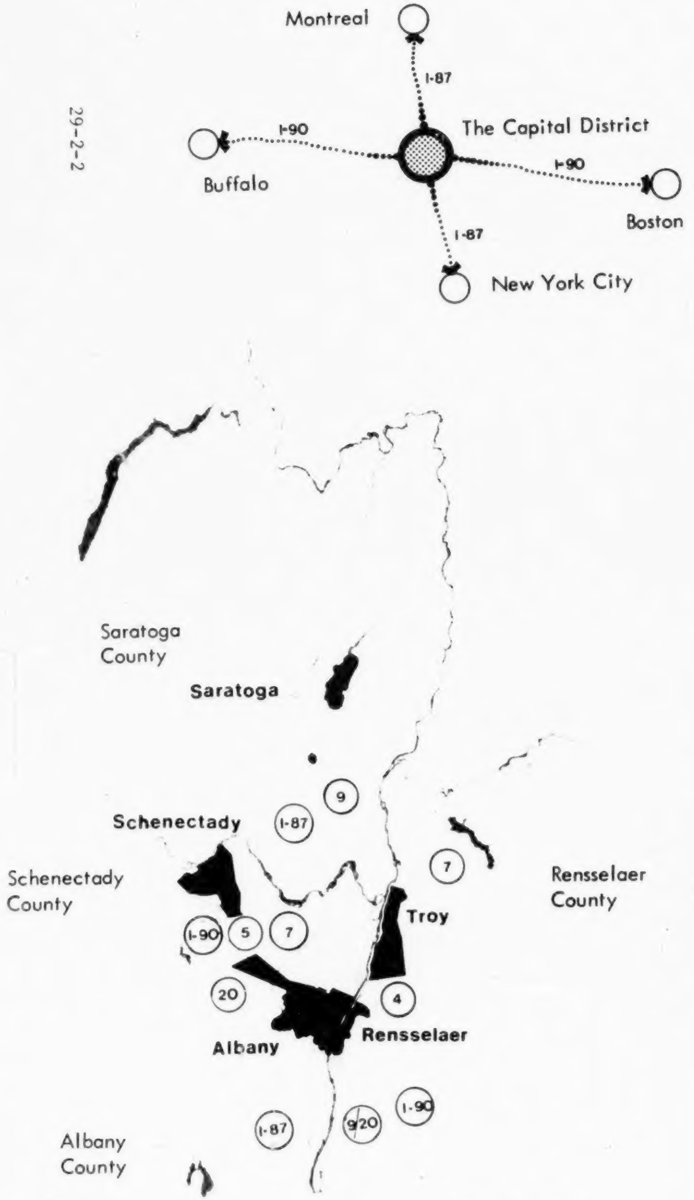

Montreal
I-87
The Capital District
I-90
Buffalo
I-90
Boston
I-87
New York City
Saratoga County
Saratoga
9
Schenectady
I-87
Schenectady County
7
Rensselaer County
Troy
I-90
5
7
20
4
Albany
Rensselaer
I-87
9/20
I-90
Albany County

Figure 1
SITE LOCATION

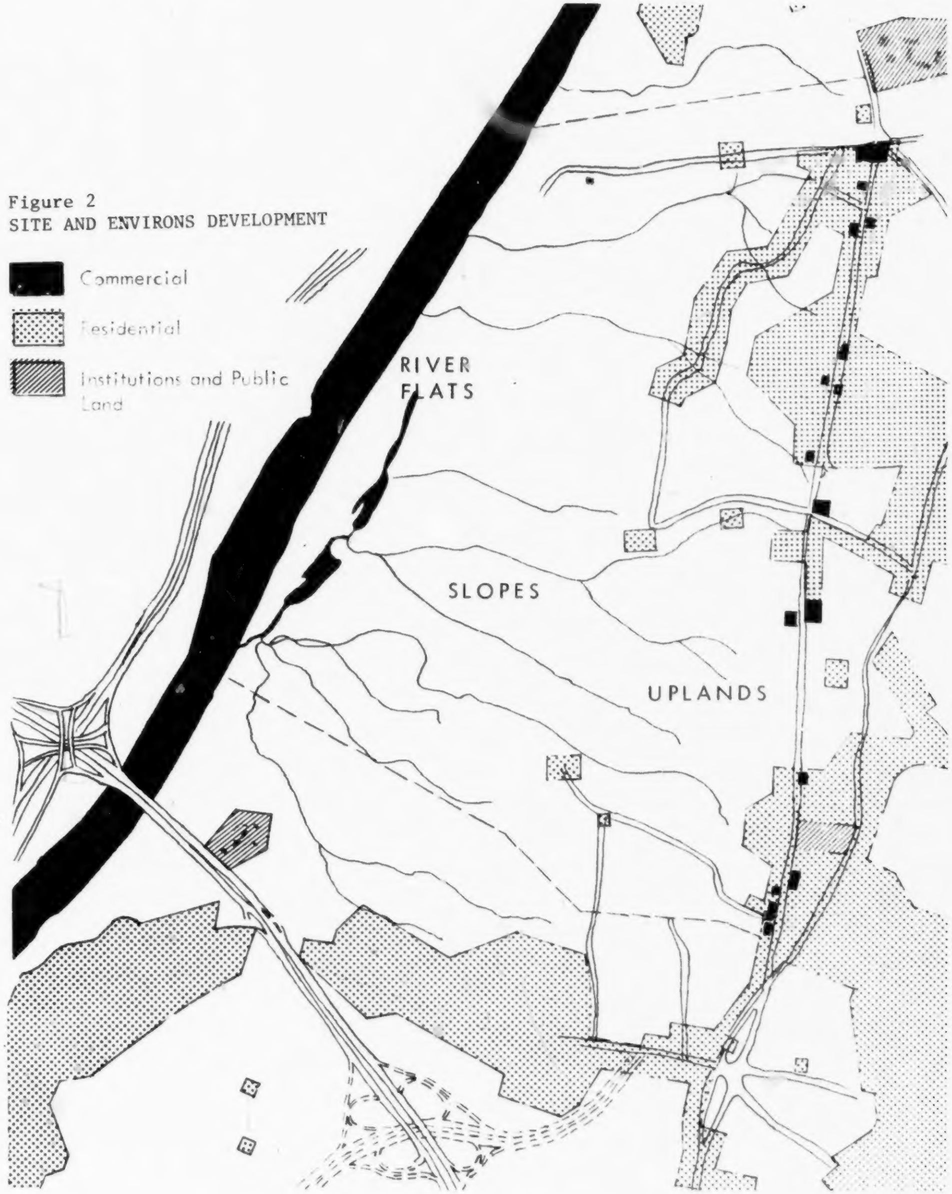


Figure 2
SITE AND ENVIRONS DEVELOPMENT

Commercial
Residential
Institutions and Public Land
RIVER FLATS
SLOPES
UPLANDS

Put plainly, the land resource has begun to emerge as a significant development potential.

The State's planning agency has recognized this and, considering its central location and undeveloped nature, has from time to time considered the possibility of it's development as an alternative to the sprawl now gripping the area. Ed Logue's Urban Development Corporation has indicated an interest in the land. RPI, as the major landholder in the site area, asked an internationally known planning firm to study its potential in 1968.

By 1969, an available land resource, a time for its development, and a concentration of interest had come together. Needed was a final element: some sort of catalyst, to "put it all together".

Before looking at that catalyst, and at what ensued, perhaps this is the appropriate time to underscore the point just made. The key initializing element in the Highlands Project is the land resource itself, as well as its location in a specific regional context. Without the land, and without the particular shifts in development taking place in the region mentioned above, there could have been no project. We will come back to this point later.

Getting the Ball Rolling

Back to the catalyst. What particular combination of people and interests got the ball rolling? These kinds of questions are never easy to answer. As we look back on the project, though, perhaps these specific elements are worth mentioning:

- The land, and the potential associated with its development, caused much interest in the university, and in some of its academic areas (notably architecture and urban-environmental studies).
- The administration and trustees of the university sensed that the time had come, and began to intensify their concern that development of the land serve the university's image, and financial and educational goals.
- The prospect that something might happen attracted some key faculty members to the institute. Notable was the addition of E. M. Risse, a planner with land use and development interest and consulting experience.
- A newly-formed Urban-Environmental Studies program, an independent effort with no disciplinary "home" on campus, began looking for possible projects on which to focus its academic and research efforts.

As these interests and resources began to coalesce, a planning/research proposal was initiated. Because of their obvious interests in the site, federal planning agencies were contacted about support of the program.

After several months of discussion and negotiation with the state planning agency (Office of Planning Coordination, now Office of Planning Services) special 701 planning funds were made available in the U.S. Department of Housing and Urban Development for the project, and a 701 planning contract was written with Rensselaer Polytechnic Institute as the contractor for the work.

As implied, this was not done overnight. 18 months elapsed from the first feelers to HUD, OPC and regional and local agencies to a signed contract for the work. Many of the problems are typical of landing any contract. Many are not:

- Academic programs in universities have traditionally not been involved in planning projects. A 701 program demands a workable study proceedure leading to application and not just an academician's view of what might be "good to do". 701 sponsors had to be convinced that RPI could do the job, that it could do a reputable job, and that it could do a job within the time and money constraints.
- A comprehensive planning effort requires a multiplicity of talents: economics, markets, transportation, housing, community organization, financing, land development, etc. Universities often include these talents among their faculties, but have not been noted for their ability to put these talents together for a particular mission quickly or effectively. This had to be proven, too.
- A university speaks with many voices. Channels of communication from the people who would do the work to those who would sponsor the effort had to be opened and kept clear. All of this was complicated by the many academic programs involved in the effort, and by Rensselaer's role as landholder, investor, and generator of income for its educational programs. Fortunately, Rensselaer is not a large and complicated place, and even given the standard internal conflicts and clouded communications network, it was ultimately possible to "speak with one voice" to the sponsor group.
- A final problem has to do with the nature of the sponsors themselves. A 701 program includes two-thirds federal participation (HUD), one-sixth state participation (OPC) and one-sixth local participation. Because of its interest in the site, the Urban Development Corporation put up the local share. Since the site is part of four-county region, the regional planning agency had to approve the study. To assure maximum fit with subregional

development, the county planning agency was asked to support the effort, and finally, RPI itself contributed some staff participation and a reduction in its normal research overhead percentage as its own share. Keeping all these balls in the air during the negotiation period proved to be no mean task.

Each of these are worth pointing out for two reasons. Not only were they hurdles to be crossed as the project was initiated, but each become a key determinant of just how the project would be accomplished. The last point in particular -- the juggling of many balls to assure maximum contribution and support for all major elements in the region, as well as all relevant agencies and groups at the state and federal levels, become a key characteristic of the Highlands Project.

Organizing Internally to do the Work

A contract with the New York State Office of Planning Services was signed in November 1970. Because of strings attached to the 701 money, June 30, 1971, just seven months later, was established as the completion date. The ground rules were set.

To get the project off to a running start, these moves were made: (Figure 3)

- A full-time planning director was brought to RPI to supervise the day-to-day operations of the project directly under Professor Risse. Fortunately, a Community Renewal Program in an upstate city was just winding down, and a competent project planner/economist was available for the job. (Many "feelers" for this position were out during the negotiation period, but it was, of course, impossible to commit anyone to this non-academic position until a contract was signed).
- A separate project "office" was established -- with accommodations for the continuing staff, the planning director, a secretary, housing for personnel contributed by the regional and county planning agencies, and "project associates".
- Key members of the faculty in architecture, transportation, management and other areas who had participated in proposal development were immediately commandeered for part-time contribution.
- Professional consulting firms representing expertise not available on the project team were retained in three areas: real estate and economics, landscape planning, and new communities development. Once again, these firms were kept "on line" during the negotiation process and commitments firmed when the contract was written.
- A group of five graduate students was immediately pressed into action as project associates. Given the possibility of the Highlands Project, they had begun academic work related to possible participation in the project in September, and other monies found to support their assistantships until the project commenced formally. They were moved into the project office and assigned tasks related to their academic interests.
- The Center for Architectural Research, a unit in the School of Architecture with considerable experience in undertaking wide variety of research work, set up the administrative machinery to guide the project as well as contributing staff and student expertise to the effort.
- Contacts in neighboring colleges and universities with potential interests and capabilities in participating in such a project were exercised. Particular interest and help were developed in local programs in public affairs and ecology.
- The meetings began.

External Operations

Perhaps as important as internal organization was how the project staff organized to handle external relations.

Put simply, the project was conducted in a fishbowl. Contrary to the pattern of most private large land development projects which operate in the dark until all of the requisite land is optioned and plans are firmed, and even contrary to the pattern of many publicly-supported projects which seek to "get their ducks in a row" before formally taking them to the public, the Highlands operated in the public eye from the start.

There were many reasons. Certainly a lot of water had gone over the dam, and many agencies and groups had already been involved in getting the project going in the first place. In 1970, the trend was moving rapidly to "citizen participation" in all phases of planning.

Probably the most significant element, though, was the role of the university as the central character in the cast. RPI is an old University and a strong force in Troy, in Rensselaer County and in the region. It is by choice a technological university dedicated to the improvement of things by the application of science and technology. Quite frankly, it was the opinion of the project staff, and of the university administration, that RPI could not realistically be connected with "just another subdivision" project." It felt a mandate to shoot for quality, to pursue innovation wherever necessary, and to involve the broadest range of participants in the process.

In pursuit of these goals,

- The existence of the project was announced throughout the academic community, in its immediate subregion and throughout the region, with participation invited.
- A regional advisory group of citizens, elected officials, and agency people was established. The group met throughout the project and was used as both a source of information and help, and a sounding board for proposals and ideas.
- Liaison was established with the relevant governing and legislative bodies in the site area.
- Holders of adjoining parcels of land were contacted and the possibilities of joint development discussed.
- A wide range of public and private firms, agencies and groups were contacted for help and for innovative opportunities.
- The project staff declined no invitation to report progress on the project to local civic organizations.

This effort was not an easy one. There are any number of places such an externally visible effort can get sidetracked. It takes one person (the project director) to provide all of the information, to travel anywhere, and to keep everyone informed and happy. There were a few minor crises in this overall effort, but generally it went well.

Project Objectives

Early in the project, the staff, working with the project sponsors and the external advisers, isolated four major determinants of development and conservation for the Highlands site: project goals, regional demographic and economic forces, the accessibility of the site to the rest of the region and the site's own natural amenities and limitations.

Project goals deserve a word, and once again the *pro bono publico* stance expected of an academic institution becomes manifest. The seven objectives set for the project included:

- Conservation of the land resource. The Capital District is being subjected to widespread and random sprawl. The site possesses a great deal of natural amenity, and the conservation of that amenity would be critical to providing a "better place" to live and work.
- Conservation of economic resources -- both private and public costs. The issue of public costs was given a great deal of attention. The staff was well aware that inattention to public costs has often forced the surrounding community to "pay" for development by providing services long after the developer has taken his profit and run. Abuses in the Capital District have already caused some communities to effectively declare moritoria on large-scale development of *any* kind while they sort things out. In the Highlands Project, financial models assessing the impact of on-site development on the local community budget, school district budget, county budget and special district budgets were developed and the development "schedules" adjusted to product positive cash flows in all accounts. (Perhaps the tactic worked a little too well: when the project planning phase results were announced in July 1971, one local newspaper carried them under a banner headline: PROJECT TO FILL LOCAL COFFERS!)
- Accommodation of both physical and social needs. Too often large-scale planning projects are pursued and developed as physical and economic constructs only. The project team spent a good deal of time in attempting to isolate social and community problems plaguing community situations now, and attempting to work these into the proposals. For example, the final work of the planning phase not only includes a feasible physical plan, but also the outline of a "Participatory Design Process" to assist a broad spectrum of lay and professional groups in actually implementing design and development on the Highlands.
- Provision of a regional example. One of the obvious prospects for the Highlands, once again furthered by the fact of university participation, is to provide a regional example of a better place to live, to recreate and to work. Even though it is an old and stable region which has not taken growth in the last two or three decades particularly gracefully, the Capital District provides an ideal place for experimenting with alternatives: it is a highly service-oriented region, it has managed to attract its share of younger and smaller households, and state development policy suggests additional growth of these opportunities in the Hudson-Mohawk corridors.
- Realization of owner expectations. In addition to some of the more basic motivations just expressed it is evident that any development on the site must meet owner expectations -- or it won't happen. For RPI, this means generating some sort of predictable and positive cash flow (either from participation in development itself or in reinvestment of "take-out" funds from sale to a developer entity). For the other landowners, it means meeting reasonable profit expectations.

- Achievement of public/private consensus. The Capital District is not a "glamor" region which automatically attracts a great deal of private money. For this and for other reasons (the high proportion of unbuildable land, the expected slow but stable growth rate, and the innovation and regional example goals), it has been obvious from the start that development of this site will require a unique consensus of public and private interest and participation.

- Realization of innovation on the site. Closely associated with the "regional example" goal is that of innovation. This goal becomes not only desirable but almost necessary when a university group decides to affiliate itself with this kind of project: simply maintaining the status quo in terms of social, community, economic and physical problems -- that is, not taking some step forward -- is out of the question.

  As a result of this concern, the project staff spent a good deal of time in investigating and proposing innovation opportunities in,

  COMMUNITY STRUCTURE AND SERVICES: establishment of a "new community" creating a sense of community, building "places to live", structuring open space, overcoming isolation and alienation, seeking new roles for institutions, looking at a community health system, community organization and decision-making.

  TECHNOLOGY: telecommunications, transportation, solid waste disposal, and consumption of energy.

  PHYSICAL DESIGN: looking at ways of better handling community facilities, community spaces, mixes uses, the "street scene", relation spaces, housing mix, housing design and construction.

  PLANNING/IMPLEMENTATION PROCESS: looking at ways of improving the process of bringing a new community into being, with particular attention to the roles that the many relevant constituencies can and should play in actual design and implementation.

  RELATING THE EDUCATIONAL ENTITY TO THE COMMUNITY: it would be folly to plan for innovative development on the Highlands site without paying particular attention to potential relationships of Rensselaer and its sister institutions in the Capital District (already organized into a consortium) on the site. Educational, research and community/regional service opportunities were explored (an remain under consideration and development).

Accomplishing the Work
Effecting development/conservation proposals which given the necessary weight to each of these objectives is no mean task, particularly in a very short period of time.

It required that the project staff be off in several directions at one time--with discussions on any given day ranging from soils tests to relocating a major power line (or, alternatively, burying it) to contacting a potential private firm with telecommunications interest and assessing interest in participating to bugging the Census people to release 1970 data for market analysis.

To accomplish these diverse goals, the project was broken into major task areas (this laid out during the proposal phase as evidence of our ability to do the work at all!)

Natural Characteristics and Development Limitations
Housing and Development Feasibility
Community Organization and Facilities
Transportation
Development Plan and Design
Financing and Management

Beyond the core professional staff (numbering 8 professionals— 6 faculty members of RPI -- and 5 student project associates), and the Program Advisory Group (numbering 22 persons), an additional 38 people from both within and without the academic community volunteered to serve on advisory groups for each of the tasks noted above. In a retrospective count of persons with whom the project staff met during the study, another 120 people are tagged as "participating".

To maintain interaction among all of these diverse elements was not an easy task. During the critical synthesis phases of the project (occuring during the middle third -- in the months of March and April), it was necessary to convene the core project staff, associates and (often) consultants on a weekly basis. Given the range of additional commitments nearly each of these people faced, the meetings were held at odd hours and on Saturdays. (A new definition of interdisciplinary research and development work: "work done on Saturdays"!) Tempers frayed, and there were times when the project director simply had to ride with a heavy hand ("Shout loudly and carry a big stick").

Another problem arising from this interaction-rich environment was what to do with the many loose ends and "hot ideas" which arose during the course of the project. Particularly in looking for a regional alternative and opportunities for innovation, there were many "leads" which simply could not be carefully explored, researched and tied down during the seven months of work. One result: a rather conventionally-appearing physical plan (with a rather conventional market analysis and financial evaluation -- to assure that it can be done) and a series of "add on" ideas for further exploration. Another result: a 360 page final report into which we attempted to pour everything we knew about the site, about the region, about the determinants of development, and about some of the non-conventional possibilities for implementing it.

The Results

On the 30th of June, 750 copies of the planning phase report were submitted to the sponsors and the public. The report calls for the conservation of approximately 1,000 acres and intensive development of the remainder of the site as a new community. (Figure 4)

This community would be oriented to a movement corridor linking downtown Albany with downtown Troy and providing for the high transit use which is made possible by the construction of the South Mall where there are 17,000 jobs and 3,000 parking places. The Mall has already spurred the start of a regional ride-park system.

The site would accomodate the regional ride-park facility for central Rensselaer County, a sub-regional commercial and community focus for the emerging Town of North Greenbush which now has a population of 10,000 and is projected to grow to 60,000 by 1990. The new community would provide for housing, service, recreation and some job opportunities for a resident population of about 13,500.

As suggested earlier, the report presents not only a physical plan but also the framework for a "participatory design process" which would utilize all relevant groups (potential residents, local residents, professionals, agency representatives), a series of "charrette" opportunities, and the development of feedback systems within the community as mechanisms for allowing people to "design" the community as they go. In many ways, the participatory design process is a logical extension of the multi-faceted participation concept developed during the study.

Planning Phase Follow-On

The report was well received, and the project director and the Center for Architectural Research were asked by RPI to develop specific evaluations of various approaches that Rensselaer, as the major landowner, might use to implement development on the site. Recommendations were presented to the President and Board of Trustees in early October, and the Board is now considering its next steps.

Since the 30th of June prospective private participants especially in the areas of communication, transportation, housing and solid waste have been contacted. Landowners and public agencies which might participate are currently in the process of negotiating the possible formulation of a development entity which would be responsible for the outline of a development entity which would be responsible for carrying out development.

Some Reflections

Even though the authors lack the perspective of time, some initial reflections can be recorded and passed along to others who may be interested in exploring new community development within the academic context.

UNIVERSITIES AND NEW COMMUNITIES. There are many attractive reasons for becoming involved in new towns - a new beginning; an opportunity to examine most of the questions involved in urban development and urban life. David Crane has recently pointed out that nations have historically become interested in "new" towns at times when the "old" towns had the most sev problems. This is as true for the Greeks, Romans and in the middle ages and during American colonization as in the mid-19th century, the 1930's and now.

What better focus for considering the problems of new communities than the academic environment? At least 20 universities in the United States are involved rather directly in the development of 150 or so new communities in some form of development at the present time. These include the University of California at Irvine; University of New York at Buffalo; University of Minnesota; Antioch College; Governors State University, Illinois; Jackson University; University of Northern Colorado and others. There is hardly a university in the United States which does not have some investigation of participation in the new community movement.

New community offers a number of challenging opportunities for the academic institution to apply knowledge to improvement of man's environment -- not to some mythical utopia but just to avoid continuing to do what we now know to be wrong.

Perhaps the greatest challenge is to the behavioral scientists who are only beginning to become concerned with the impact of the environmental design process. At least one major new community consultant in the United States is attempting to bring these behavioralists into the development activity, new community development process.

From the point of view of physical design, it takes only a quick review of the major new communities currently under development in the United States to see that they have been turning out conglomerations of the same old models, the same clustering of housing, the same back turned on the rivers, the neighborhoods cut up with roads for cars, the same waste of energy for heating and air conditioning, the same paving of land.

Housing is another possibility for innovation with the new community aggregating markets sufficient to test new methods of construction and new design. Likewise, new configurations of development offer opportunities for testing new methods of waste collection and treatment.

In the technological area perhaps no area is more important than achieving a new balance between transportation and communication. The coming communications revolution will have a profound effect on our lives and the physical form of our communities; unless this is examined and perhaps best examined in the format of a new community, the impact is likely to be less than desirable.

Better communications allow the person within the urban context to know better what is close at hand and he therefore can walk or use some other low energy consumption method of close-in transportation. It allows him to know of a job of interest or find acquaintances with mutual interests without traveling across the city or the region. Better local communications provides for the pooling of shared interests for recreation, education or economic advancement. It provides a way of finding out about services close at hand.

Better communications allows a person to know more about things at a distance and therefore he does not have to travel to learn about them. This includes remote shopping, access to information and remote participation in business, political and educational activities.

Better communications allow a person to bring activities to themselves. Perhaps one of the most important activities would be bringing work to the neighborhood rather than hauling people to work in the familiar twice a day rush. We already bring recreation in the form of television programming to the home; many other forms of recreation could be added when the communications revolution lowers the cost and expands the opportunities. Information and education could be brought to the person more easily than people can be brought to it.

An integrated telecommunications network could provide these services:

- entertainment
- information dissemination
- education
- commercial services
- financial services
- postal services
- health
- welfare
- private and public safety
- traffic control
- utility monitoring
- private communications

If, as has been recently suggested, that transportation is a waste to be minimized and not (except for recreation) to be a goal in itself, then the trade-offs between transportation and communication appear to be an important area of innovation -- and one suitably appropriate for university participation.

PROBLEMS ASSOCIATED WITH ACADEMIC PARTICIPATION. This paper has attempted to point out many of the large and small problems encountered when academia takes on a new community planning project.

Perhaps most significantly, it ceases to be traditional academia, geared to mulling things over for a good long time before organizing for action. Organization for action must be accomplished immediately (even while soliciting funds for the work!), and it requires the dedication of people who want to get things done.

Projects like the Highlands tend to contradict long-held views of what is acceptable as "research" in academia. If we in the architecture and planning professions are educating people who *do* things, though, it can be argued that research and development opportunities which put students and faculty in the position of doing are appropriate -- and even necessary -- for good education.

The Land and the Region as the Real Client

Experience on the Highlands Project indicates that to be meaningfully involved in new community development there needs to be *more* than academic interest.

During the planning phase and in the negotiations that have been carried out since, an "environmental ethic" of some magnitude has emerged: the *land* and the *regional context* within which it functions, are the real clients for the development of a new community. There must be land, and that land must have the potential to make a significant contribution to the urban fabric. Both parts of the equation were there in the Highlands Project.

In this case, the land and the context attracted the generalists and specialists who formed a team to investigate its development and conservation potential.

This emerging view of the Real Client is, in the authors' view, superior to, but compatible with, the traditional views of the client as either a private enterprise seeking profit, or a public agency attempting to carry out its mission. The land and the context can attract new and innovative private enterprises who see strong markets for their interests in the decades of the 70's and 80's: as well as a wide range of public agencies. (In the Highlands Project, several public agencies beyond those with planning responsibilities participated in meaningful ways: mental hygiene, education, environmental conservation, transportation public service commission.)

The Information Problem

One of the most significant obstacles encountered in the program so far has been the inability to get information on new community development. The development industry has always been fragmented and frequently different segments of the industry do not know what others are doing. At the scale of a new community this becomes a more serious problem. Experience during the studies indicated that those involved in private sector development treat the information they have on new communities and how they ought to be developed as corporate secrets - as well as the profit of the development may well turn on effective application of some trade secret or gimmick. U.S. Department of Housing and Urban Development, per haps the natural agency to operate a clearing house for information has not seen this as being one of their functions.

This problem may soon reach crucial proportions. There are perhaps 400-500 new communities under consideration in the U.S. Assuming that 100 of these are developed, they might within the next ten years house 5 million people. If none of these profit from the experience or knowledge possessed by others, then there is a serious danger of losing the potential and in fact developing real problems which scuttle the whole movement and its potential.

In Conclusion

It is too early to tell whether or not the Highlands Project has been a "success". Success can ultimately be gauged only by the quality of the environment which evolves on the site. If it is a substantial contribution to the region and to our knowledge of new community development, then the project will have been successful.

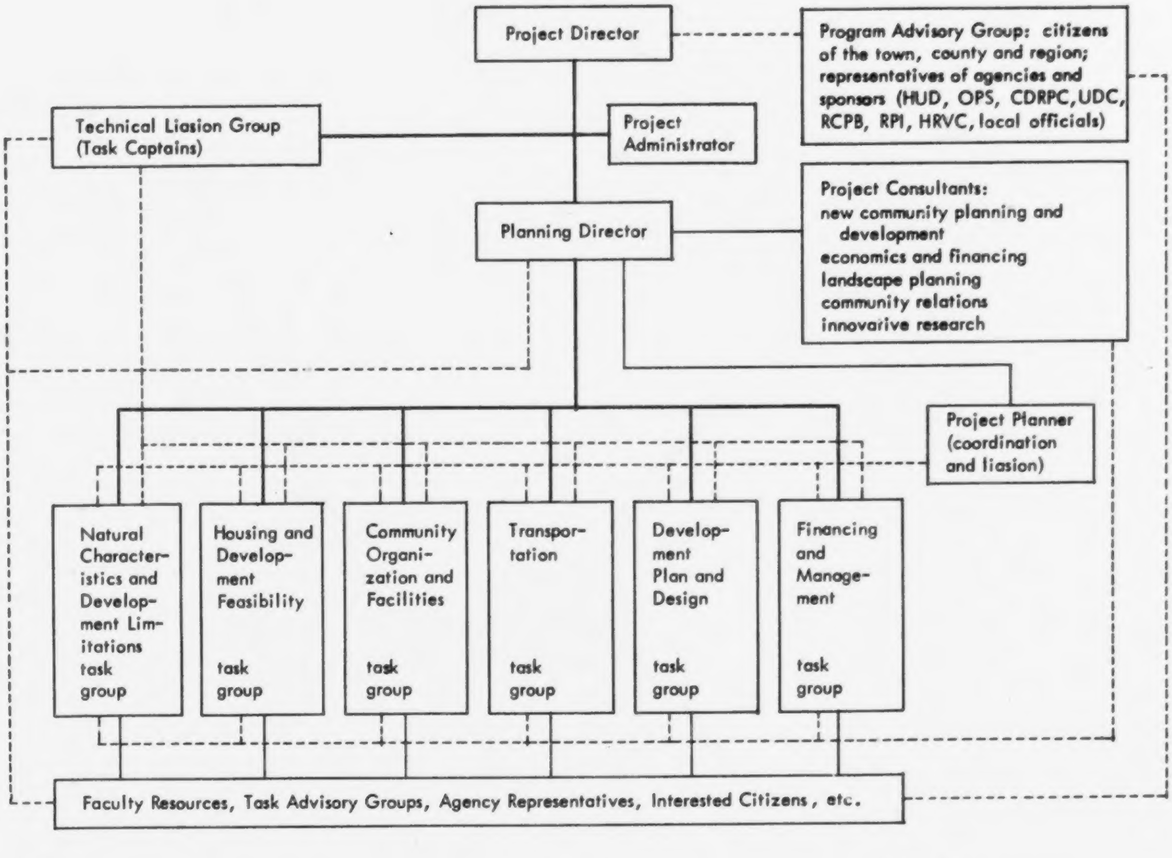
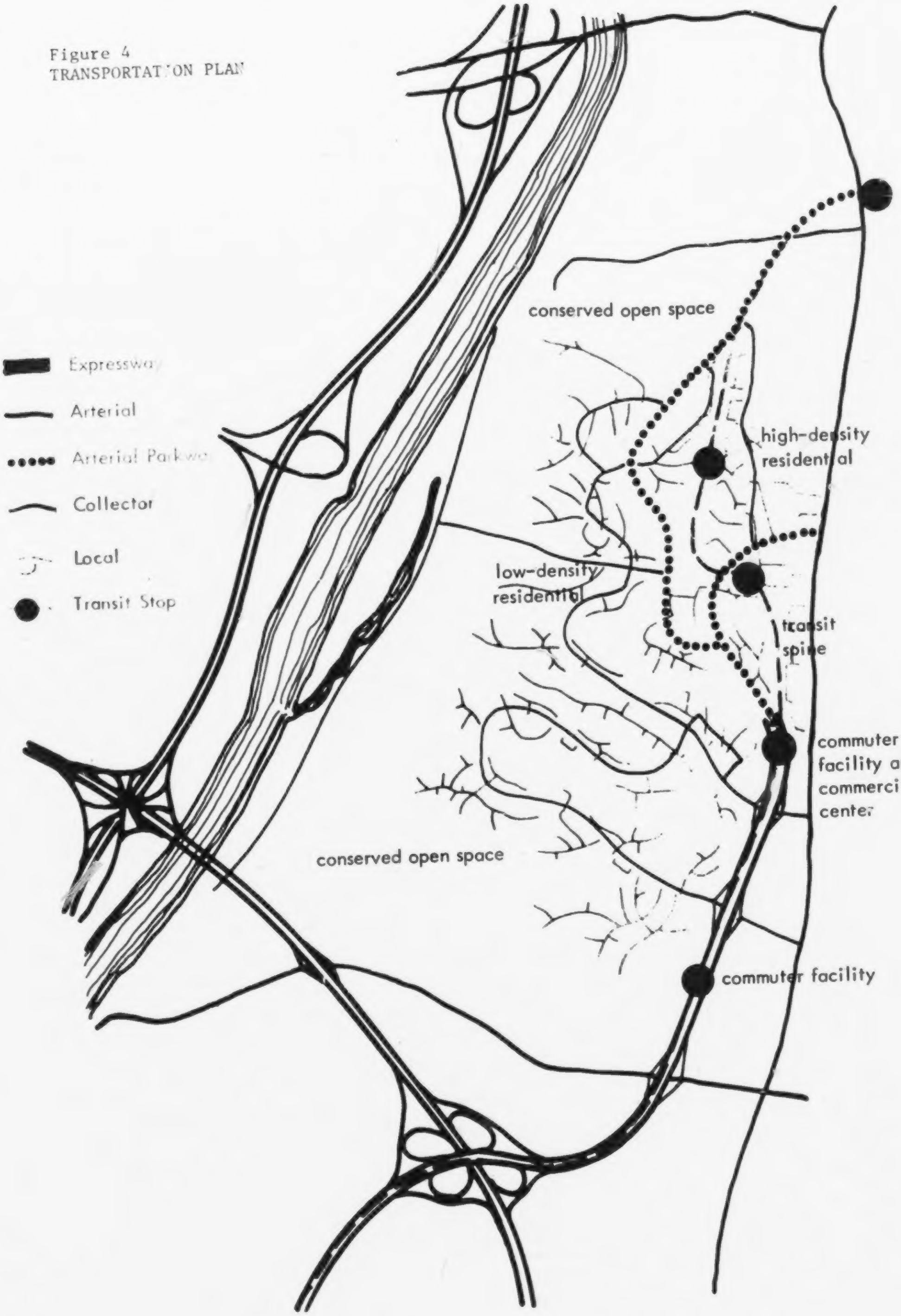

Project Director
Program Advisory Group: citizens of the town, county and region; representatives of agencies and sponsors (HUD, OPS, CDRPC, UDC, RCPB, RPI, HRVC, local officials)
Technical Liasion Group (Task Captains)
Project Administrator
Project Consultants: new community planning and development economics and financing landscape planning community relations innovarive research
Planning Director
Project Planner (coordination and liasion)
Natural Characteristics and Development Limitations task group
Housing and Development Feasibility task group
Community Organization and Facilities task group
Transportation task group
Development Plan and Design task group
Financing and Management task group
Faculty Resources, Task Advisory Groups, Agency Representatives, Interested Citizens, etc.

Figure 3
PROJECT ORGANIZATION

Figure 4
TRANSPORTATION PLAN


Expressway
Arterial
Arterial Parkway
Collector
Local
Transit Stop
conserved open space
high-density residential
low-density residential
transit spine
commuter facility and commercial center
conserved open space
commuter facility

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Abstract

The desired outcome of environmental research is usually seen in terms of scientific knowledge and rules which decrease the designer's reliance on intuition and rules of thumb in solving problems. The corollary of this idea is that design methods must be systematised in order to assimilate such knowledge. These two notions form the basis of a kind of paradigm for environmental research and its usefulness. It is argued that this paradigm is based on simplistic notions about knowledge and about design, that design problems are essentially pre-structured both by constraints and by the designer's own cognitive map, and that solutions are only intelligible if this is fully recognised. Design proceeds by conjecture-analysis rather than by analysis-synthesis. It is argued that if research is to make an impact on design it must influence designers at the pre-structuring and conjectural stages. The idea that research should produce knowledge in the form of packaged information, coupled to rationalised design procedures is therefore inadequate. The aim of research should be seen more in terms of providing designers with a stronger theoretical, operational and heuristic basis from which to conjecture, rather than in terms of knowledge to determine outcomes.

Note (1)
In this paper the words 'architecture' and 'architectural' are used as shorthand for the built environment and its action systems, as a sub-system of environmental action and modification as a whole. It is not intended to refer to the activities or ideology of a particular professional group. We apologise for any confusion this may cause.

Note (2) -
The analysis in the early part of the paper refers principally to the UK situation as it has developed in the last fifteen years or so, but we hope that the arguments will retain most of their validity when applied elsewhere.

This paper is about knowledge and design Before you reach for your hats, we should add that it is intended to be a technical not a theological contribution to the subject. We offer it, not because we have no research to report, or because we think this conference is in need of philosophic homilies, but because we believe we are up against some fundamental limitations in the arguments which have been used to justify research and to define its tasks.

Research of one kind or another has now a longish history in building. By and large, this increased investment in research has proceeded side by side with a marked deterioration in the quality of building. A serious 'applicability gap' appears to exist. Regardless of the quality of research work itself, the history of attempts to link research to improvements in environmental action is largely one of confusion and failure. (1)

When the concepts of 'environmental research', as opposed to technologically oriented building research, began to emerge a decade or so ago, there seemed to be good reasons for hoping that these new concepts in research would lead to new relationships between research and action. At that stage, when the ground was being cleared for the expansion of environmental research, programmatic statements took a clear line.

Ten years ago, when the ground was being cleared for great expansion of architectural research activity, programmatic statements took a clear line. Design was a problem-solving activity, involving quantifiable and non-quantifiable factors. Research, it was thought, should bring as many factors as possible within the domain of the quantifiable, and progressively replace intuition and rules of thumb with knowledge and methods of measurement. This process would never be complete. Non-quantifiable elements would remain. In order to assimilate such knowledge and use such tools as we were able to bring to bear on design, the procedures of designers would have to be made more systematic. Because the education of architects was broad and shallow, and because they were concerned with action rather than knowledge, they could not be expected to generate new knowledge for themselves. This was the job of 'related' disciplines, whose concern was the advancement of knowledge. Architects, on the other hand, knew about design, and should make systematic design their research focus. Otherwise their contribution to research lay in technological development, or as members of multi-disciplinary teams, in defining the problems for others to solve.

The educational consequences of these notions were that schools of architecture and planning were to be located in an educational milieu containing a rich variety of related disciplines, and students were to be well grounded in each of them. The core of the architectural course would still be design, and, at the academic level, this meant increased concentration upon systematic methods. Students would be taught to analyse problems, and to synthesise solutions.

A few voices crying in the wilderness that architecture contained its own fundamental disciplines could not stop the onward march of these simple and powerful ideas, and by and large, they still hold the stage today. But if these are to be the paradigmatic ideas by which we define our subjects and link them to action, then today's landscape, (although promising in that other disciplines are developing their latent 'environmental' interests), must appear depressing. Systematic design studies are in disarray. Increasing numbers of research workers, including architects, are moving into the areas previously called 'unquantifiable'. There is a widespread feeling that an 'applicability gap' has developed between research and design. Design is still led by the nose by technology, economics and imagistic fashions. The human sciences and architecture are still at loggerheads. Education, with few exceptions, has not managed to develop a radically new capability in the problem-solving power which students bring to design.

In fact, we are far from pessimistic about the progress of architectural research, largely because a great deal is now happening that cannot be explained in terms of the ideas we have outlined above. The situation has outstripped the paradigm which gave birth to it. But the intelligibility of the situation is poor, perhaps because it is inconsistent with the paradigm. We require some radical overhaul of its assumptions - particularly those to do with the relationships between knowledge and design, and the presupposed polarities (e.g. rationalism/intuitionism) along with a new effort to externalise the dynamics of the new situation. To us this seems to be an essential step before the 'applicability gap' is compounded by a 'credibility gap' arising from the gulf between what is expected of research, and what research appears to be offering.

Perhaps the simplest way of introducing what we have to say is by drawing an analogy with the slow but decisive shift in philosophy and scientific epistemology over the past half-century or so. Implicit in both the rationalist and empiricist lines of thought was the notion that in order to get at truth, preconceptions must be eliminated or at least reduced to the minimum. Rationalism began its long history by proposing a priori axioms whose truth was supposed to be self evident; empiricism relied on the neutrality of observation. Since the early part of this century, developments in such areas as psychology, meta-mathematics, logic, and the philosophy of science have combined to show that both of these are impossible and unnecessary to an account of scientific progress. Far from being removed from the field of science, the cognitive schemes by which we interpret the world and pre-structure our observations are increasingly seen to be the essential subject matter of science. The question is not whether the world is pre-structured, but how it is pre-structured.

Too often these developments appear to have escaped the attention of scientists working in the environmental field and designers interested in research and looking to research for solutions to problems. This is particularly unfortunate, because the idea of pre-structuring has immediate and fundamental applications in design. We cannot escape from the fact that designers must, and do, pre-structure their problems in order to solve them, although it appears to have been an article of faith among writers on design method (with a few exceptions(2)) that this was undesirable because unscientific. The nub of our argument is that research in the field of the built environment and its action systems should see as its eventual outcome and point of aim the restructuring of the cognitive schemes which designers bring to bear on their tasks, not in terms of supplying 'knowledge' as packaged information to fit into rationalised design procedures, but in terms of redefining what those tasks are like, and using the heuristic capability of scientific procedures to explore the possible through a study of the actual. It is our view that the notion that well packaged knowledge coupled with a logic of design can lead to radically better artifacts, on the evidence we have, should be relegated to the realm of mythology. But in arguing our case we would like to say a little more about why we think modern scientific epistemology has an important bearing on design and meta-design (which we will argue is probably the simplest and most adequate characterisation of design research) and why it can help us reconstitute our paradigmatic notions about the subject.

Fifty years ago, it was still possible to think of science as ultimately constituting a set of signs which at the most rudimentary level would bear a one to one correspondence with atomic facts, and that these could eventually be combined by the laws of induction and verification into a pyramid of laws of greater and greater generality. Scientists on the whole believed this to be the case, and philosophers concerned themselves to show how it would be accomplished.

The overthrow of the Newtonian account of the universe, previously taken as the paradigm of positive knowledge arrived at by observation and induction (as described by Newton himself), threw scientific epistemology into a crisis, the effects of which are still with us. We will give a brief account of this later on. Shortly afterwards, even more remarkable and undermining developments took place in the foundations of mathematics and logic. Gödel showed, by his incompleteness theorem, that 'the construction of a demonstrably consistent relatively rich theory requires not simply an 'analysis' of its 'presuppositions', but the construction of the next higher theory with the effect', to continue quoting Piaget, that 'Previously it had been possible to view theories as layers of a pyramid, each resting on the one below, the theory at ground level being the most secure because constituted by the simplest means, and the whole poised on a self sufficient base . Now however 'simplicity' becomes a sign of weakness and the fastening of any story on the edifice of human knowledge calls for the construction of the next higher theory. To revert to our earlier image, the pyramid of knowledge no longer rests on its foundations but hangs by its vertex, an ideal point never reached and, more curious, constantly rising. (3, 4)'

This is of vital importance, not simply because it demonstrates the inherent limitations of formalism, and the impossibility of such notions as the class of all classes, or the single unified science, but because it demonstrates that there is a necessary hierarchy which limits what we can mean by knowledge - the hierarchy of meta-theories and meta-languages, independent of (we can think of it as orthogonal to) the hierarchy of levels of integration of phenomena in the 'real' world, which constitutes the formal basis of most scientific disciplines. Any cognitive formalisation takes a lower order formalism for its object and can itself become the object of a higher formalism. To quote Piaget again : 'The limits of formalism can, more simply, be understood as due to the fact that there is no 'form as such' or 'content as such', that each element - from sensory motor acts through operations to theories - is always simultaneously form to the content it subsumes and content for some higher form.' (5)

If we accept that the idea of a monumental edifice of knowledge, descriptive of the world in its account of facts and explanatory of them in terms of theories of increasing generality, has to be given up, what have we left? Have we not effectively debunked the idea of knowledge? Having got rid of positivism, are we left with pure relativism? Intuitively, we feel that such a retreat cannot account for the success of science in improving our understanding of the world and our capacity to modify it. If we adopt a position of pure philosophic relativism then relativity (in theoretical physics - we are short of terms here) and the atomic bomb appear as a kind of epistemological paradox. If on the other hand, we accept that there are strong reasons for rejecting both positivism and pure philosophic relativism, then where do we go? It seems that, as with Scylla and Charybdis, we cannot escape the one without falling into the other.

It is against this background that the achievement of scientific philosophers like Karl Popper, Thomas Kuhn and Imre Lakatos take on their full stature. Popper has demonstrated that a logic of induction and the principle of verification, previously the twin pillars of positivist science, were both unattainable and unnecessary, and that science could be contained within a hypothetico-deductive scheme: (6) Kuhn suggests a changing epistemological paradigm, within which science can operate as a puzzle solving activity until the next revolutionary 'paradigm switch'(7). Lakatos reconstructs science as conflicting sets of inter-related theories (on a smaller scale and more volatile than Kuhn's paradigms), retaining the idea of a 'negative heuristic theoretical core' and a 'positive heuristic' puzzle solving area, each of which exhibits at any time either a 'progressing' or 'degenerating' problem shift according to whether or not it is able to predict new phenomena within its basic theories without having to add ad hoc hypotheses to account for newly discovered phenomena. (8) Then we have a reconstruction of science which is able, in a highly non-linear way, to account for its own continuity, as well as offering some rational justification for using the word 'knowledge' perhaps, to use Popper's expression, as 'piles in the swamp', the swamp being essentially the infinite regress of meta-theories and meta-languages.

The simplest reconciliation of these lines of thought in meta-mathematics and the philosophy of science is to state frankly that the object of science is cognition, and that it is the strategems of science that are directed towards the real or empirical world. More precisely, we could say that science is about 'remaking cognition', it being clear that if we were satisfied with our cognitive codes for deciphering the world, we would not have science. This seems to us an adequate resolution of the old philosophical problem of whether the 'world out there' or our perception of it is the more real. Such a definition is implicit in the work of psychologists like Kelly, who characterise everyday behaviour by analogy with scientific behaviour. (9)
It is a small step to reverse the argument, and it allows us to account not only for the preoccupation of science with the empirical, but also for the fact that some advanced areas of science - notably certain branches of theoretical physics - have had no means of contacting the empirical world for about forty years. We would hardly be satisfied with a characterisation of science which relegated theoretical physics to the realm of metaphysics.

How does all this help us with architectural research? First, it should be clear that once we move away from the establishment of basic criteria set up with a view to avoiding physical discomfort (which we knew how to do anyway in pre-scientific days) then we can avoid a lot of misconception about the status of 'knowledge' in design. Secondly, we can begin to see the problems raised by the paradigm for research in architecture that we outlined at the beginning of the paper. Thirdly, it provides us with a better method of making fertile analogies between and thus in connecting the activities of scientists and designers.

The paradigm we suggest as underlying most current research activity in architecture appears to be based on two notions about science that take no account of the developments we have outlined: the notion that science can produce factual knowledge, which is superior to and independent of theory; and the notion of a logic of induction, by which theories may be derived logically from an analysis of facts. In the paradigm, these two notions appear to constitute the fundamental assumptions on which the whole set of ideas is founded: first, that the role of scientific work is to provide factual information that can be assimilated into design; second that a rationalised design process, able to assimilate such information, would characteristically and necessarily proceed by decomposing a problem into its elements, adding an information content to each element drawn as far as possible from scientific work, and 'synthesising' (i.e. inducting) a solution by means of a set of logical or procedural rules.

So far we have suggested very theoretical reasons why such ideas would not be viable or realisable. But equally, from the more practical point of view of the designer or the student, the ideas - or more precisely the operational consequences that flow directly from them - appear even more unviable. Designers are left to make their own links with research by assimilating 'results' and quantification rules, and to evaluate them as they appear without guidance on priorities or patterns of application. The designer's field thus becomes more complex and less structured. It follows that if a designer cannot make use of this 'information' he is forced to the conclusion that it is because his procedures are not systematic enough, with the result that if he tries to improve himself, he immediately becomes preoccupied with means at the expense of ends.

Similar consequences flowed from these twin paradigmatic assumptions in architectural research itself. For example, building science as a university discipline tended to remain separate and independent of the design disciplines, usually as a research-oriented service-teaching department, sometimes even generating the packages of knowledge that were to fit into the rationalised design procedures. In trying to formalise the process, designers were forced into developing concepts like 'fit' and 'optimisation' simply in order to complete the line of logic by which a 'synthesis' could be accomplished, even though such notions are highly artificial in terms of what buildings are really like and are actually refuted by considering buildings as time-dependent systems rather than as once-and-for-all products.

Our negative aim in this paper was to try to show why the advance of research related to design has so far appeared to progress in parallel with deterioration in the acceptability of the designed product - and this, in the UK, in spite of two decades of excellent work by such bodies as the Building Research Station and government departments, well disseminated in intelligible form and often containing mandatory requirements. We hope that we have shown that there are both theoretical and practical reasons why such a state of affairs should not surprise us. If the present paradigm is unworkable in its essentials, what can we put in its place? We have to preface our proposals with some suggestions about the nature (the actual nature as well as the desirable nature) of design activity.

It is not hard to see why the analysis-synthesis, or inductive, notion of design was popular with theorisers and even with designers as a rationalisation of their own activities. The architectural version of the liberal-rational tradition was that designs should be derived from an analysis of the requirements of the users, rather than from the designer's preconceptions. It is directly analogous to the popularity of induction with scientists who were anxious to distinguish their theories as being derived from a meticulous examination of the facts in the real world. The point we are making in both cases is not that the ideas are immoral or fundamentally deceptive - scientists do describe meticulously the 'facts' of the situation, and designers do pay attention to the details of user needs - it is that they are theoretically untenable and unnecessary, and as a result, practically confusing.

The first point we would like to make about our version of science in relation to design is that if scientists really operate by a kind of dialectic between their prestructuring of the world and the world as it shows itself to be when examined in these terms, then why should such a procedure be thought unscientific in design? Why not accept that only by prestructuring any problem, either explicitly or implicitly, can we make it tractable to rational analysis or empirical investigation?

The second point is also in the form of a question. If rationality in design is not to be characterised in terms of a procedure that allows the information to generate the solution, then in what terms can it be characterised? Is it a redundant notion? Is there any alternative to the mixture of intuitive, imitative and quasi-scientific procedures which appear to characterise design as it is carried out? We would like to work towards answers to both of these questions by using some of the ideas we have discussed in a kind of thought experiment about the nature of design.

First, some observations about reflexivity (cognitive activity making itself its own object, or part of its object) and meta-languages and meta-theories (cognitive activity making other cognitive activity its object.) These, it would appear, have clear parallels at the social level, in terms of the progressive differentiation of roles, especially in areas like design where physical activity is preceded by cognitive and reflective activities. For example, if we start with a simple picture of a man making an object, then it would be reasonable to argue that in as much as he has a definite cognitive anticipation of the probable object (i.e. he is not simply experimenting by trial and error with the latencies of his tools and raw materials) then he is acting analogously to a designer as well as being a maker. His cognitive anticipation of the object is part of the field of tools and raw materials that constitute his 'instrumental set'. Design as we know it can be seen as the socially differentiated transformation of the reflexive cognition of the maker in terms of the latent possibilities of his tools, materials and object types. Its object is not the building, but at one remove, sets of instructions for building. The activity called architectural research can be derived by an exactly similar transformation, namely a socially differentiated transformation of the reflexiveness of the activity of design upon itself i.e. its object is design, and its product takes the form of rules or rule-like systems for design which stand in the same relation to design as design does to building. As in other sciences, it finds the best way of doing this is by addressing most of its strategies to the 'real' world, and if we are not careful this coupled to the fact that the activity is necessarily multi-disciplinary, tends to conceal the 'deep structure' of the activity. This is why we suggested earlier that we should call the research activity meta-design. At least this might begin to emancipate us from the silly (but pervasive) idea that the outcome of research is 'knowledge', to be contrasted with the absence of such 'knowledge' in design.

We can perhaps clarify the characteristics of design as a cognitive activity by going back to the very simplified situation we have just referred to, to see if we can discover what there is in the maker/designer's field, and go from there to see how it differs today. Here we owe some debt to Levi-Strauss' discussion of 'bricolage' as an analogy to myth making. (10)

We can imagine a man and an object he will create as though separated by a space which is filled, on the one hand, with tools and raw materials which we can call his 'instrumental set', (or perhaps technological means) and on the other, a productive sequence or process by which an object may be realised. If time is excluded from the space, we can conceive of the 'instrumental set' as though laid out on a table, and constituting a field of latencies and preconstraints. If time is in the space, then the instrumental set is, as it were, arranged in a procedure or process.

The total field thus exhibits two types of complexity, and we may allow that the maker is capable of reflexively making both types of complexity (the latencies of the instrumental set, and the distribution in process-time) the objects of his attention.

Two basic strategies appear to be open to him. He can either distribute the latencies of the instrumental set in process-time according to some definite cognitive anticipation of the object he is creating, i.e. pursue a definite design or plan, which may be based on an analogy or on pure imagination, as it may be conceived in terms of the familiar products of the instrumental set. Or he can, as it were, interrogate his instrumental set, by an understanding of its latencies in relation to general object types. In both strategies an understanding of the latencies of instrumental sets and a general knowledge of solution types is of fundamental importance. In other words, the maker's capability in pre-structuring the problem is the very basis of his skill, even if he wishes to proceed heuristically by interrogating his instrumental set and exploring unknown possibilities by a dialectic between his understanding of the latencies and limitations of the instrumental set and his knowledge of solution types. On this basis we would argue that design is essentially a matter of pre-structuring problems either by a knowledge of solution types or by a knowledge of the latencies of the instrumental set in relation to solution types, and that this is why the process of design is resistent to the inductive-empiricist rationality so common in the field. A complete account of the designer's operations during design, would still not tell us where the solution came from.

But there is an escape clause. As with science, it is not a matter of whether the problem is pre-structured but how it is pre-structured, and whether the designer is prepared to make this pre-structuring the object of his critical attention. From here we would go on to suggest that the polarisation we have assumed between rational and intuitive design should be reformulated as a polarity between reflexive design (i.e. design which criticises its understanding of the latencies of instrumental sets and solution types) and non-reflexive design (i.e. design which is simply oriented towards a problem and which therefore operates within the known constraints and limits of instrumental sets and solution types). To equate rationality with a certain type of systematic procedure appears therefore, quite simply, as a mistake.

It is obvious that today the designer operates in a field which is considerably more complicated than the one we have described, based on a man making an object. The notion of pre-structuring is necessary to any conceptualisation of design, but not sufficient in itself. We have to look at the complications and how they have evolved, in order to complete our conceptualisation of the designer's field and his operations in it.

The most obvious difference is that design is not simply the reflexive/cognitive aspect of making an object, but a separate, socially differentiated activity with its own internal dynamic and its own end product, namely sets of rules for making artifacts. It is also a highly specialised activity, carried out by a clearly defined social group. There is therefore no direct link between interrogating the instrumental set and the result as it is likely to be experienced by those who use it. We thus require a great deal of information about the latter in order to interrogate the instrumental set.

We can explore the consequences of this development by trying to imagine what life was like when we had designers, but not user requirement studies. How did we live without them? The answer seems quite simple. Notions about the user were built into the instrumental set and the solution types. The instrumental set was comparatively unsophiscated and had in any case been developed mutatively over a long period. It was already an expression of the basic physiological requirements of users in terms of available technology, and probably a reasonable approximation of their psychological and other expectations. The solution types had been similarly evolved, and contained already the notions of use and activities within the building. We could say that, contained in the instrumental set and the solution types was an implicit, historically evolved code, which linked the means to the ends. It would be difficult to decipher and reconstruct, but we can see that it was there, and, in principle, how it got there.

Since those days we have seen developments like the proliferation of building types, and the proliferation of instrumental sets (technological means) and a formal organisation of the process which results in most activity being of a one-off kind with the simple effect that the users' needs in terms of activities, physiological requirements and cultural expectations are no longer contained, as it were, in the instrumental sets and solution types. A much freer, more indeterminate situation appears to exist. This deficiency is made up in terms of information which is expressed in terms of the users rather than in terms of buildings, and the designer operates a kind of informal code for linking one to the other. Part of the outcome of research in the past has been a piecemeal and atomistic partial replacement of the codes, by formal rules which when implemented often have the unfortunate effect of dictating the whole design (the 2% day light factor is a classic example). The designer's task becomes something like the utilisation of these codes in order to link the information he gathers about the project to his interrogation of the increasingly prolific instrumental sets, or his manipulation of solution types. He has to deal similarly with the proliferation of information extraneous to the particular problem relating to standards, constraints, quantification rules etc.. In this situation it is perhaps no wonder that the designer (unless his ambitions are frankly artistic) welcomes the prospect of a logic whereby solutions can be synthesised out of information. It offers him the prospect of eventual escape from the contradiction of actually working by the interrogation of instrumental sets or the adaptation of solution types, as he always did, but being expected to utilise a procedure of optimising information which bears little relation to building, except where piecemeal atomistic rules have been developed. Perhaps we should add one more point to this analysis: that the informal codes the designer must use to link information to built outcomes are also instances of problem prestructuring.

If this is a reasonable characterisation of the principle elements in the designer's field, then at least we are some way to understanding why designers do not produce better buildings out of the information research provides, and why, with expanding technological means and user requirements the theoretical open endedness of architectural problems lead to so little fundamental variety in the solutions proposed. With a proliferation of poorly understood instrumental sets, increasingly masked by unrelated information, we would expect that a retreat to the most basic form of pre-structuring - the adaptation of previous solutions - would become the only viable way through the morass. Far from helping the designer escape from his preconception, the effect of proliferating technology and information, is to force the designer into a greater dependence on them. Innovation becomes more rather than less difficult, but the diffusion of uncritical innovation would become more rapid. A situation develops in which a few experiment and others adapt solution types, without understanding or evaluating the rationale of the original experiment. The net result is unstructured innovation, with slow and piecemeal feedback, giving the impression of arbitrary shifts in fashion. This seems a not unreasonable account of the situation we have, and would explain why even well disseminated and well presented information - such as widely exists in the UK from BRS and government departments - either does not lead to an improvement in the product or does so only in a haphazard way.

We would also suggest that this leads to a situation in which students are learning two different and largely unrelated strategies: methods of analysing a problem into its elements; and a knowledge of informal codes and solution typologies, which they pick up almost as by-products of architectural education, and which act as the pre-structuring that enables them actually to design buildings.

We have argued that the chief elements present in the designer's field are knowledge of instrumental sets, knowledge of solution types, informal codes, and information. These cannot usefully be reduced to homogenised 'information', although it is possible at a theoretical and formalised level. Now we would like to use these ideas to try to construct a lifelike conceptualisation of design as an activity.

These elements constitute the designer's field, his set of latencies and preconstraints. Somehow these are to be distributed in a process time. We will need to introduce one or two further basic ideas as we proceed, but we hope that these will either be from those we have already discussed, or simple logical statements of an unproblematical kind.

For example, it seems unproblematic to say that when a design problem is stated there are, theoretically at least, a number of solutions open, probably a very large number. Yet only one of these possible solutions will be the final one that is built. We may reasonably say that some process of variety reduction has taken place. The variety of possible solutions has been reduced to one unique solution by some means. The succession of documents produced during design reflect this progressive reduction of variety. More and more specific drawings for example exclude more and more detailed design possibilities. We would like to introduce this as a basic idea in our conceptualisation of design.

A second idea we would like to introduce is that of conjecture. Here we would like to go back to science. It was once thought that conjecture would have no place in a rigorous scientific method. It was thought to be akin to speculation, and science sought to define itself in contradistinction to such notions. Since Popper we know that science cannot progress without conjecture, in fact that together with rigorous means of testing, conjectures constitute the life blood of science. Conjectures come from anywhere, and because they are not derived from the data by induction, it does not mean that the process of thought of which they form part is any the less rational or rigorous. What is irrational is to exclude conjecture. So we will include it in design.

How does the reduction of variety from many possible to one actual solution take place? Obviously anything we can say here will only be an approximation of any particular case. But our aim is to try to understand the process of design as it exists in the real world, in order to try to define the contribution of meta-design. What we are aiming at is some more or less true to life approximation of the psychology of design, bearing in mind that design is a practical as well as a cognitive activity, and that design problems do not happen in a social vacuum, but are socially constructed.

Beginning with a theoretically open problem, with an unlimited number of solutions, it should be clear that the variety of possible solutions is already reduced before any conscious act of designing begins by two sets of limiting factors, one set external to the designer, the other internal. The first set we can call 'external variety reducing constraints' and these can often be quite powerful, or even totally deterministic of the design. For example a client who says categorically 'I want one like that' has already reduced the number of possible solutions to one. More often the external constraints will be of a less overt, but still powerful, kind, such as norms of appearance, availability of technological means, costs, standards and so on. Some of these will not be fully understood by the designer at the outset, but as he specifies them their role as variety reducers will become clearer.

The second set we can call the 'internal variety reducers' and these are an expression of the designer's cognitive map, in particular his understanding of instrumental sets and solution types. This notion of the pre-existing cognitive map is very important indeed, because it is largely through the existence of such maps that any cognitive problem solving activity can take place. They are, and must be used by the problem-solver in order to structure the problem in terms in which he can solve it. It acts as a kind of plan for finding a route through problem material that would otherwise appear undifferentiated and amorphous. Its role is equivalent to the role of theory and theoretical frameworks in science. Data is not collected at random. What is to be called data is already determined by some prior theoretical or quasi-theoretical exercise, implicit or explicit.

We have to recognise, therefore, that before the problem is further specified by the gathering of data about the problem, it is already powerfully constructed by two sets of limiting factors· the external constraints (although some of these may still be poorly understood) and the designer's cognitive capability in relation to that type of problem. It is quite likely that these latent limitations are already being explored right from the beginning, if the designer is conjecturing possible solutions, or at least approximations of solutions, in order to structure his understanding of the problem, and to test out its resistances. There is also a very practical reason why conjectures of approximate solutions should come early on. This is that a vast variety of design decisions cannot be taken - particularly those which involve other contributors - before the solution in principle is known.

As the designer collects and organises the problem data, and data about constraints, his conjectures acquire sharper definition. Previously he was not able to test them out in a very specific way. Now he has an increasing fund of information against which to test them. He will also be using this information heuristically by using it in relation to his informal codes (see above, p 8) by which abstract requirements are linked to built outcomes, and conjecturing further specifications within his roughly conjectured solutions. Information which has been used heuristically, can also be used to test the new conjectures. Conjecture and problem specification thus proceed side by side rather than in sequence. Moreover conjectures do not, on the whole, arise out of the information although it may contribute heuristically. By and large they come from the pre-existing cognitive capability - knowledge of the instrumental sets, solution types, and informal codes, and occasionally from right outside - an analogy perhaps, or a metaphor, or simply what is called inspiration. At least within this conceptualisation of design we do not have to say that designers who use these last three types of source for conjecture are acting in a way that is markedly different to the architect with more modest ambitions. He has simply widened the scope of his conjectural field, sometimes moving right beyond the limits of the instrumental sets that are available.

When a conjectural approximation of a solution stands up to the test of the increasingly specific problem data (bearing in mind that it is always possible to collect more data and to produce more conjectures) a halt is called to both conjecturing and data gathering, and a solution in principle is agreed to exist. Further specification then takes place (i.e. further variety reduction) by completing a full design, and this is followed by a further refinement when the final production drawings are made. Unless the designer has great foresight, it is likely that further refinements will be made at the building stage.

We believe that this is more or less how design happens in most situations, and we believe moreover that it is as rational a process as is possible in the complex circumstances, not sub-rational because it is not 'systematic' and because so much depends on how the designer pre-structures the problem. This outline model differs from the analysis-synthesis model (which we take to be the dominant notion in design method studies, hitherto) in several important ways. First, its core strategem is conjecture-analysis rather than analysis-synthesis. Secondly the purpose of analysis is primarily to test conjectures rather than to optimise by logical or magical procedures. The notion of optimising which architects believe they carry out can be easily contained within a conjecture-test psychology of design. Thirdly the solution in principle is allowed to exist at a much earlier stage than in the analysis-synthesis model. Fourth, the model shows the path of convergence on a unique solution without introducing notions like the optimisation of information which, while attractive theoretically, are largely unlifelike and unworkable. Fifth, the model suggests within its basic concepts the possible origins of solutions in principle, a matter on which the design methodologists are notoriously silent or mysterious. Sixth, the model corresponds to the observed sequences of products of design, namely a set of descriptive documents of increasing refinement and specificity. Seventh, it recognises implicitly that both information and conjectured solutions are inherently incomplete, but a stop has to be called somewhere. This is precisely equivalent to the situation in science. Eighth, and perhaps most important, the model emphasises the importance of the designer's pre-structuring of the problem, rather than denigrating it. It recognises that architects' approach - and should approach - design holistically and not piecemeal.

What does this have to say about research? We have already argued that presenting the 'results' of research in the form of packaged information or quantification tools does not seem to lead easily to better solutions. Perhaps the model will help to explain why. It is largely because unless research can influence designers at the stage of pre-structuring the problem in order to understand it, then its influence on design will remain limited.

To explore this further, we might usefully examine the outcomes of research in terms of the four main types of elements which characterise the designer's field, namely instrumental sets, solution types, codes and information. It can be seen that much research of a purely technological kind (still by far the largest investment in building research) has its outcomes in terms of instrumental sets. Development work extends this into solution types by proposing exemplars. Research which aims to provide a method of checking design proposals against abstract requirements can be seen as a partial formalisation of codes (partial because it is concerned with testing rather than generation and it is piecemeal). And research which has its outcome in the form of 'results', rather than a tool, falls into the field of information.

It can easily be seen that the first and last of these do not really help the designer to design. They normally increase the complication of the field and obscure its structure. Certainly they do not help the designer much at the stage of pre-structuring the problem, and if they do so, it can only be in a haphazard way. The exemplars and prototypes that are the outcomes of development work certainly help the designer to pre-structure his problem, but only if he proceeds in a largely imitative way. If the development is inadequate in any respect, it leads to a proliferation of these inadequacies. Over and above this, the prototype may be poorly understood, or badly adapted. Research in the third category is similarly unhelpful at the crucial stage of pre-structuring. It may provide a means of eliminating errors at the design testing stage, given that the designer is able to use them properly, but we can hardly conceive of the designer being able to effectively utilise the full panoply of such techniques that would be required to cover all aspects of the design.

Of the four, only the development model can demonstrate to the designer new ways of pre-structuring his problem. In spite of its disadvantages, its potential usefulness should not be under-estimated. We could say that it suggests an organisational solution to the problem of linking research effectively with design. If research workers work with designers in producing experimental prototype solutions, which are intensively monitored and improved, then explained and publicised, then research itself benefits by becoming part of a dynamic process from which it can continuously learn and develop its concepts. In the past, development work in building has tended to lack both the deep involvement of research workers, and a properly developed monitoring function linked to a building programme. If both of these are provided for, there is at least an opportunity for sustained development over a period. By the quality and conviction of its exemplars, it can lead quite rapidly to a diffusion of real improvements in solutions.

On the other hand, the disadvantages of relying wholly on this fail-safe means of linking research with design are strong. The individual designer becomes severely constricted, problems of poor interpretation and debasement are likely to arise, creative innovation may be cut off or inhibited. Is there not some way in which research may help the designer to pre-structure his problems more effectively without pre-determining the solutions?

We believe there is, and that it lies in the notion of codes, the third element in the designer's field. Informal or implicit codes, we suggested, were used by the designer to link abstract functional requirements with instrumental sets, which no longer contained such codes. Taken together as a system, they constitute a kind of quasi-theory by which the designer structures his problem and finds a route through it - or through as much as is left of the problem after other external and internal constraints, including solution types, have had their say. Sometimes these codes are formalised and externalised in a rather pragmatic and programmatic way as 'architectural theory'. The influence and rate of diffusion of such externalisations is often very considerable. (11) On occasion their impact is such as to have a marked effect on the development of instrumental sets.

The idea we are working towards, stated simply, is that research should aim (and already is beginning to aim) at the progressive reconstitution of the codes on a conceptual base by studies of people and their built environment which are oriented towards theory rather than 'results'. This is a complex and long term aim, but it is entirely consistent with the normal impact of scientific work on human activities. The difference between a craft and a technology is not research results, but theory which brings structure and classification into phenomena, and allows the possible to emerge from an understanding of the actual. In any problem-solving activity, theory is the essential link between science and action. Without theory and its classificatory and route-finding possibilities, design is likely to remain, even in a field of endlessly proliferating scientific 'information', a kind of craft without continuity.

Here we come back to the reasons for optimism about architectural research. It seems to us, that we are seeing the development of strong research programmes which are architectural in that they deal with broad bands of connected factors in design, and fundamental in that they are concerned with theories which actually relate to these levels of integration, rather than theories about isolated factors in environment. We would therefore like to try to explain what we see as the emerging structure of architectural research, why it is theoretical in a design as well as a scientific sense, and why it appears capable in the long run of affecting the ways in which problems are pre-structured by designers.

We can best explain this by asking a question. What, in theoretical terms, is a building? On the grounds that buildings are not gratuitous but entirely purposeful objects, we would define a building as a realisation of a number of social functions with an effect of ecological displacement. By specifying these functions and displacement effects in sufficiently abstract terms, we can formulate an adequate theoretical description of what a building is (such that anything which lacks one of them is not a building, and that if an object is a building, it will fulfil all these functions whether by intention or as a by-product) and what its displacement effect is in terms of a four-function model. These are not true for all time, but are an historically accumulative set which define more or less what a building is at this point in time.

First, a building is a climate modifier, and within this broad concept it acts as a complex environmental filter between inside and outside, it has a displacement effect on external climate and ecology and it modifies, by increasing, decreasing and specifying, the sensory inputs into the human organism.

Second, a building is a container of activities, and within this it both inhibits and facilit activities, perhaps occasionally prompting them or determining them. It also locates behaviour, and in this sense can be seen as a modification of the total behaviour of society

Third, a building is a symbolic and cultural object, not simply in terms of the intentions of the designer, but also in terms of the cognitive sets of those who encounter it. It has a similar displacement effect on the culture of society. We should note that a negatively cultural building is just as powerful a symbolic object as a positively, (i.e. intentionally) cultural one.

Fourth, a building is an addition of value to raw materials (like all productive processes), and within this it is a capital investment, a maximisation of scarce resources of material and manpower, and a use of resources over time. In the broader context of society, it can be seen as a resource modifier.

In brief a building is a climate modifier, a behaviour modifier, a cultural modifier and a resource modifier, the notion of 'modification' containing both the functional and displacement aspects.

Each of these functions can be conceived of separately as a people-thing relationship and each, in contrast to research orientated towards the 'atom of environment' deals with a holistic set which constitutes one way of looking at a design problem. Each is capable of developing theory about people and their built environment. We would argue that research is gradually organising itself within these foci as a set of interdependent, theory oriented and largely structural studies, and that these are emerging as the fundamental disciplines of architectural research, and providing the base within which various disciplines become integrated and lose their identity.

It is notable, by the way, that the emphases implicit in this model shift architectural research right away from the study of procedures of design and into the study of buildings and their occupants, as well as away from 'results' and towards theory. We are beginning to look again at ends rather than means.

How will such research contribute to design? We have argued at the general level that it will progressively enable us to reconstitute codes from a theoretical base concerned with the relations between physical environments and those who experience them. We may add first that we conceive of this happening not in a positivistic and piecemeal way, but, because of the theoretical base, in a more holistic, non-deterministic and heuristic way. But this is too general a statement to be useful. We must specify further what we mean, and show why we can use this idea to escape from the idea of once-and-for-all 'knowledge' and allow for fundamental shifts in the theoretical bases by which we define 'knowledge' which will undoubtedly occur. We appeal again to the lessons of science.

In spite of periodic epistemological crises, paradigm switches and the progression and degeneration of research programmes, science continues to build its usefulness (as it has always done) on the strength of precise descriptions of the world. The theories on which these precise descriptions are based may be incomplete and even wrong, but they enable us to organise more and more of the world into useful cognitive schemes which, among other outcomes, enable us to conceive the possible out of a study of the actual. It might not be going too far to characterise the history of science as a series of immensely fertile delusions.

We do not therefore need to invoke the idea of 'knowledge' in order to propose that out of the notion of a building as a multi-functional object, and design as a multi-theoretical activity, we can begin to build up theory-based descriptions of the basic elements in design. These basic elements include ranges of activities, movements, perception motivated actions, social intercourse patterns, spaces and the environmental criteria that will satisfy a classified range of possible uses, coded and described in terms of the technologies which make them possible. Such a breakdown we might call a base component classification for environmental action, which would shift both in response to theoretical changes and also in response to changes in the environmental objectives of society. From the point of view of the designer. Such classifications and code formalisations would not be deterministic or constitute a set to be specified in relation to problem information, but would constitute an extension of the designer's basic cognitive capability, and provide him with - and this is really the point about science - a position of strength from which to make his conjectures. In other words he would be using theories operationalised and specified as far as possible in terms of externalised codes, linking instrumental sets to human usage, as a basis for proposing his own further modifications to the environmental field.

The implications of this for the current formal structure of design activity - particularly those concerned with briefing, one-off user studies, and the designer's ability to re-interpret the 'client's requirements' - are enormous, and to examine them in detail would require another paper. To give one example, in the area of activity-space relations, we can foresee the possibility of moving from the 'activity-space fit' notion which is implicit in current practice, towards much more fundamental theories about the capability of certain types and configurations of space to contain an unpredictable variety of activities, perhaps with consequences for the idea of building types, and even for the size of cities. Such theories are not pseudo-deterministic ways of telling the designer what will be the outcome of his design, but strong and cumulatively developing bases for conjecturing possible futures.

If we are right in thinking that this is the underlying direction of the new lines in environmental research, then the notion of research simply as a service to design and the by-product of an eclectic variety of disciplines has to go by the board. Research is of course necessarily multi-disciplinary. In fact in the environmental field there appear to be no limits to the disciplines that could contribute to the advancement of the subject. But the contributions of the wider areas of science will only become effective through the integrative theories which will increasingly form the fundamental disciplines of environmental action itself, and these disciplines are not separate from design, but extensions of it in that their subject matter is design just as the subject matter of design is sets of instructions for building.

This is not a strange or unique arrangement. In fact it is very similar to science itself, seen in its broadest terms as one of the activities of society. Through science we continuously modify the world we live in and our understanding of - that world and that understanding that it is the aim of science to study.

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RESEARCH AND PRACTICE IN ARCHITECTURE: BRIDGING THE GAP

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Introduction

The gap between Theory and Practice in design generally and in architectural design in particular is widely acknowledged. I must make it clear that I am going to use the term Theory here rather than the term Research as in the title of this paper. Theory means the exposition of ideas and principles and thus embraces the fruits of Research.

Practice is an activity which is varied, ceaseless and covering an enormously wide field. Theory, in the usual narrow sense, in architecture is often said to be in a state of confusion. This, I suppose, means that theories of design arise at random, are publicised, discussed, taught, but never objectively tested, and ultimately they are forgotten as others appear. However, Theory, in the wider sense, which includes Research, can be seen as a varied, ceaseless and wide-ranging activity, similar to Practice yet distinct from it.

That these two fields are distinct is inevitable but the worry is that they are separated - by the gap - and not joined sufficiently well to feed each other's development through the interchange and testing of ideas, experience and expertise. One hope for giving the activities in both fields some joint coherence is to be seen in the emergence of the new topic of design studies (variously labelled Design Methodology, Design Theory, Design Science, Design Research, etc.). These studies gained definition and impetus in 1962 when the first major conference on Design Methods was held at Imperial College in London (1).

Not long after attending that conference I began the attempts at Bridging the Gap which I am going to relate here. I will be describing developments in a particular design office in Britain from late 1963 until now, a period of intensive technical innovation and change throughout the building industry and the design professions. These have included the change from the Imperial to the Metric System, the publication of two important theoretical systems for co-ordinating building communications (2) (3), the introduction of the R.I.B.A. Plan of Work for Design Team Operation (4), the first important applications of computers, and so on

The Gap Syndrome

How I came to begin illustrates the way in which the Gap is typically perceived. In this case a medium sized architects' office presents the following syndrome:-

1. Fairly rapid growth in its workload and hence its size.
2. A federal organisation, i.e. a group of partners of equal status, sharing common corporate objectives but tending to run their own jobs and teams independently within the single organisation.
3. A feeling that the advantages of the single organisation were not being exploited, e.g. some design problems were being solved differently over and over again, or even by independent teams simultaneously, due to lack of communication and feedback of experience.
4. A desire to improve design performance, which is linked to the application of research and also to the growing technical siphistication of 'clients', especially in government and industry.
5. A desire to increase productivity which is also felt to be linked with the application of research.

I think this condition arises very frequently in architects' offices and perhaps other design organisations. A typical anonymous case was described in an article in the Architects' Journal (5) almost coincidentally with my starting this work. It would be useful however to have further confirmation of this.

The Co-ordinator

Once the problem has been identified the usual response is to delegate the task of solving it as quickly as possible, so that the teams in the office can stop worrying and carry on in practice as before. If no-one already in the office volunteers a new post is advertised. The description of the job differs in each case and the special titles invented for it reflect this. They may want to set up a 'Research and Development Group' or a 'Technical Section' or to find a 'Research Director' or 'Standards Group Leader', and so on. In what follows I shall have to use a term for this function and for convenience I have chosen the word 'co-ordinator'.

At the outset I do not think the term 'Bridging the Gap' was specifically in anyone's mind. In advance of taking up the job I made the following note:

> "The office makes and sells a 'product', i.e. design. The product itself can be improved. The production process can be made more efficient."

These seemed to be my aims and I thought that:

> "Measures of design improvement and production efficiency would be necessary to assess effectiveness."

This would have been a very tall order but I was lucky, in that no criteria were ever suggested that might be applied to my performance.

On arrival I received a short paper summarising what the firm thought it wanted and a slender file holding a mixture of standard forms in use, internally drafted technical aids, ideas about job management, about building design and about detailing. These had been prepared by various senior architects in the group from time-to-time for their own use and issued for general consumption. In most design offices of any size regular meetings are held at which staff put forward and discuss ideas such as these for improving design and methods.

All those involved however are busy architects in practice with several jobs to run which are making urgent day-to-day demands on them. They know they should stop occasionally and think about their methods and frame ways of improving them but, being human, they can rarely achieve this. At first, therefore, it seemed important that the co-ordinator should be entirely free of such project responsibilities. Co-ordination is his project but as yet, whatever his initial terms of reference, there is little guidance for planning this operation.

Psychological Aspects

Fortunately I found that I had an almost open brief and a more or less unlimited time. Without being fully aware that I was doing so I made an attempt to establish satisfactory relationships with everybody in the firm. If the co-ordinator is to have any practical effect he must somehow succeed in this.

By far the most important component of his task in any organisation is a psychological one. This takes time and the more people there are the longer it will take. The co-ordinator himself cannot be a completely neutral personality and each relationship will be unique, take its own time to establish, have its own quality and its own degree of effectiveness. If he is a newcomer to the organisation he may encounter some hostility and resentment. His unusual status is ambiguous and he has somehow to prove his own professional competence at the work his colleagues are doing. This is particularly difficult when he has no ordinary project of his own. The obvious strategy is to concentrate on getting to know the Principals and senior staff as these are more permanent as well as more responsible for decision-making. They are also much busier and less accessible than the intermediate and junior staff so this strategy is hard to employ. In addition to time and patience the co-ordinator needs either special skill or luck to succeed in this to any degree worth mentioning.

I begin by stressing the psychological aspects of this work because they become evident again and again as will be seen. The first obvious technique I adopted was to set up a library and information service which this particular office did not already have. Of its many functions one was to provide theoretical and research data for the co-ordinator, to reinforce his own apparent competence and knowledge. Its overt function was to provide technical information, building regulations and standards, trade catalogues and government building documents for the day-to-day needs of the staff and this it does of course. We did however try to develop it as a focus for all enquiries and problems arising within the office in the hope of identifying conscious technical or practical needs.

Although in retrospect it seems that the most important part of the first phase was establishing personal relationships we naturally did not wait to begin to introduce ad hoc a variety of new techniques. The most successful of these was project programming and it is worth discussing in some detail.

Experiences with Programming

The programming of the building design process and the preparation of production information was, around 1963 in Britain, a generally crude business. There were exceptions of course but this, I think, is how the great majority of jobs were done:-
The client and architect agreed to a series of calendar dates for key events. The periods between were decided on the basis of experience. The unit of time used was (even for quite small jobs) six months; for tight programmes, three months was occasionally used. In a typical programme the sketch design would take six months, production drawings eighteen months, bills of quantities six months and tendering and appointment of contractors three months. The duration of the building contract was often set using similar units but within a very narrow range - from twelve months for small jobs up to thirty months maximum for the larger jobs. During the pre-contract phase,

occasional meetings were held at which delays in progress were announced and 'justified' and the periods extended by agreement. The crudity and ineffectiveness of this way of working seems incredible but even now this method is still used in places.

Just after I started as co-ordinator, it was arranged that the entire office would be introduced to Network Analysis Techniques at a series of half-day seminars organised by a firm of management consultants. Afterwards office meetings were held at which it was agreed that Network Analysis Techniques were a "good thing" and should be adopted immediately and for everything. The only problem was how to introduce the techniques and here, seen perfectly clearly, is the Gap itself. Network Analysis Techniques are a very precise example of Theory and our office was the very essence, if not the quintessence, of Practice.

Excuses were quickly found for the majority of jobs to opt out of using the new techniques. The main reasons were (a) that the clients could not be persuaded to co-operate (b) that this job was running very smoothly already, thank you, or (c) the architects simply did not have the time to carry out the extra work involved in drawing up a network analysis. This last led to a debate in the office as to whether programming (using Network Analysis Techniques) should be done individually by the teams working on the jobs or centrally for all jobs in the office by - guess who?

It was inevitable that now, with the co-ordinator established in residence he would be given this task thus permitting the job teams to relax and carry on again as before. In an attempt to alleviate his work load however it was decided that all the jobs were similar enough to be able to use a standard Network Analysis. This was to be prepared first and applied to all jobs with modifications for special circumstances where necessary.

My interest in systematic design methods and design studies, which were the subject of an increasing amount of published work and discussions, became important in this, but less so than my recent practical experience, and much less so than the strength of my various personal relationships. My colleagues had to be persuaded to adopt a standard procedure which was described in detail for work which they had hitherto been doing unsystematically. Programmes drawn up in this way were annoyingly detailed and yet could not show the specific problems and requirements of individual jobs which, to the architects concerned, seemed all important.

In translating Theory into Practice at first the former received some very rough treatment because the Standard Network Analysis turned out as follows (Figure 1):-

1. For the design process it was not a true network.
2. It had some of the characteristics of a bar chart but was not drawn to a time scale.
3. It was deliberately given a certain visual character, i.e. the design stage progresses with an increasing number of activities. This illustrated the concept of the design getting more worked out element by element.
4. The production information stage was a theoretically true network of very little practical use.
5. The analysis, and therefore the network, was fully complete only for the architects' work - not for all the other members of the design team.

At first, however, it was applied on a guinea-pig project. For this the Standard was modified, target dates were added and it was used for routine progress checks. The establishment of target dates was still done by the traditional crude method. These early networks, however, gave a more detailed and systematic description of the work to be done between target dates than any of our previous programmes.

Applying new methods quickly on guinea-pig projects is another obvious strategy for the co-ordinator and in this case was, in fact, highly successful. But of course it had to be gone through at its own pace before this success was demonstrated. This took until about the beginning of 1966 when we presented the operation to a meeting of the whole office.

Having pushed this small bridge across the gap we worked very hard at programming. Sometimes we adapted the standard network, sometimes we drew up special ones. When we began nearly all job teams were sceptical and I have no doubt that many of these elaborate programmes were drafted, drawn up, agreed and issued to clients and consultants thereafter to be totally ignored.

But we have learned from our experience, strengthening and widening the bridge, and within three years the demand has arisen for programming for all jobs. The teams take it for granted as a fundamental and indispensable service. In relation to the duration of a typical project in our office programming developed quickly. At present we only use the standard network analysis (as gradually refined over the years) on fairly small and simple projects. The majority of jobs in our office are very large and need network analyses and

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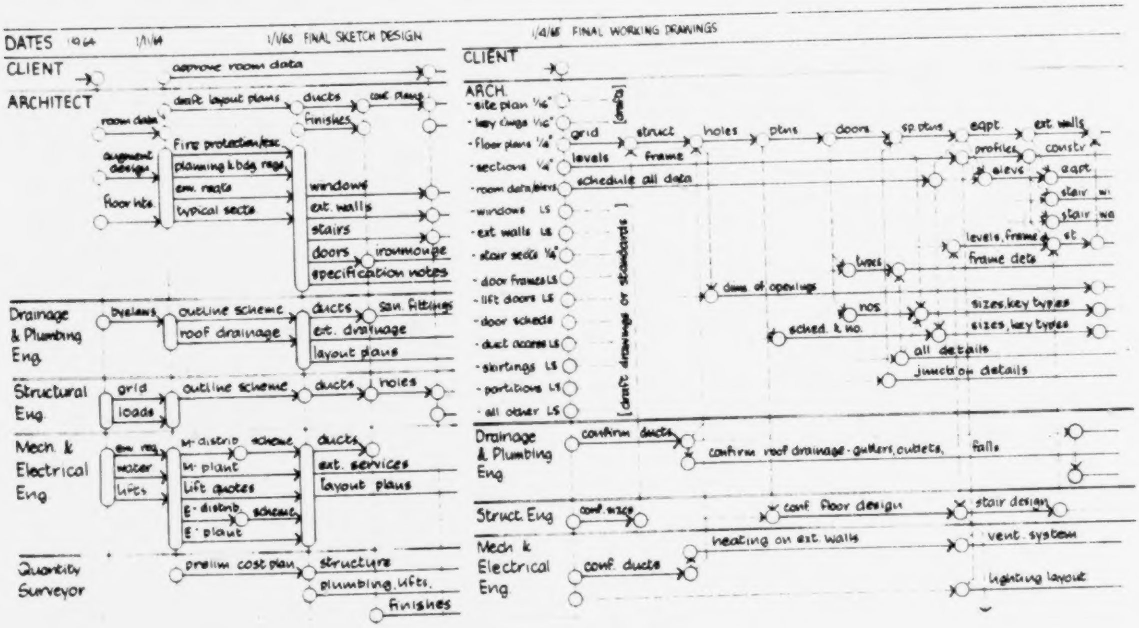
DATES 1964 1/11/64
1/1/65 FINAL SKETCH DESIGN
1/4/65 FINAL WORKING DRAWINGS
CLIENT
approve room data
ARCHITECT
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draft layout plans
ducts
finishes
fire protection/esc.
planning & bldg regs
env. reqts
typical sects
windows
ext. walls
stairs
doors
ironmongery
specification notes
Drainage & Plumbing Eng.
byelaws
outline scheme
roof drainage
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all details
junction details
Drainage & Plumbing Eng.
confirm ducts
confirm roof drainage - gutters, outlets,
falls
Struct. Eng.
conf. sizes
conf. floor design
stair design
Mech. & Electrical Eng.
conf. ducts
heating on ext. walls
vent. system
lighting layout

Figure 1. Sections of the original Standard Network Analysis

programmes specially prepared using the standard one only as a checklist. Although similar in many respects, small basic differences between jobs demand this. Drawing new programmes for each job is often easier than adopting the standard one and again it is psychologically more acceptable to the team.

The following technical features of our current programmes are notable and illustrate the construction of the bridge (Figure 2):

1. They are now true network diagrams but without exception they are drawn to a time scale. We arrived at this practice very soon after we began - sometime during 1965. It is essential to show activity arrows proportional in length to their programmed durations. This makes progress checking and up-dating simpler. A paper in 1967 by J.R. Britten of the Building Research Station confirms our experience (6). Activity arrows (but not dummy arrows) are drawn, not as lines, but as bars so that actual progress can be shown by filling them in (as in a bar chart).

2. The critical path is rarely calculated. In practice most of the target dates are set by clients or by outside authorities and programming is a matter of dividing up the available time between them for the activities needed to be done. For time units weeks and sometimes days are used. Compare this with the three or six-month units that were used before. All parties to the programme are required to confirm that they can do their own work within the times allotted and they are expected to keep to it.

3. Analyses are as coarse as possible. We do not show every activity - again because we are dealing with professionals who know their own jobs. It is quite unnecessary to show drawings being prepared, issued, discussed, revised and re-issued, etc. Parallel working is normal and often implicit in programmes.

4. Drawings are used as the principal element of our detailed programmes. Drawing is second nature to architects and as practitioners we automatically think in terms of drawing production. However, our interest in drawings and our need to know much more about them for more precise programming purposes has led to research studies of some importance to which I will refer again.

I have tried to show how we transformed an example of Theory into a specific Practice. Theorists will find this particular practice crude and imperfect. Our practitioners found the basic Theory unusable, time-wasting and wrong in its apparent aims. This gap, however, has been bridged.

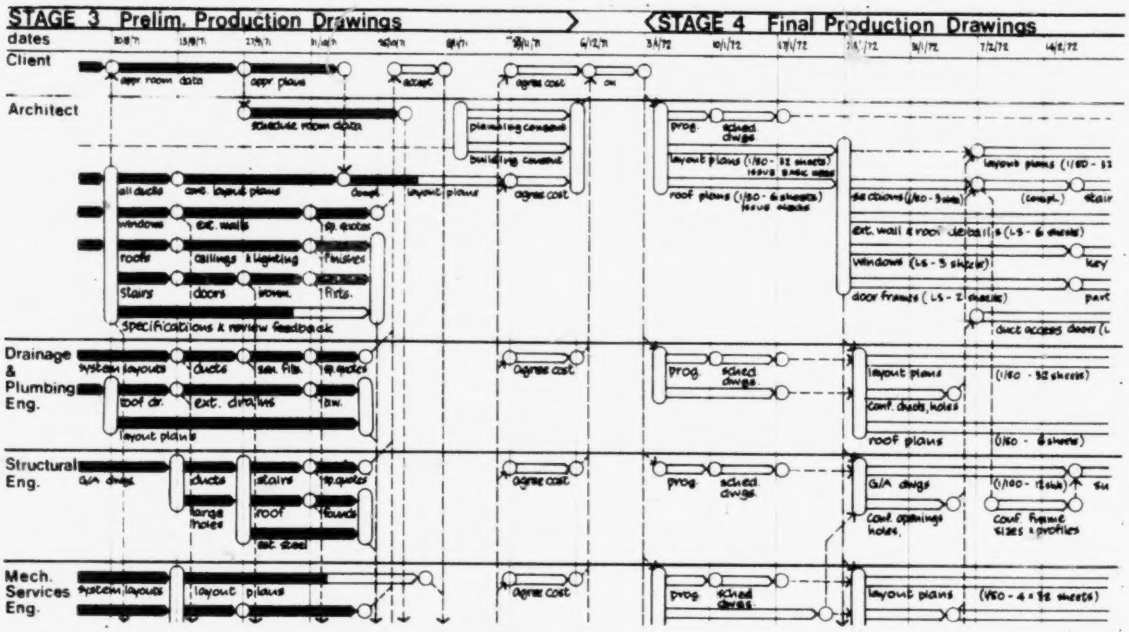

Figure 2, Section of Standard Network Analysis in current use (Progress marked by filled bars).

The Key to Co-ordination

In drawing up a standard network analysis we perforce analysed every aspect of an architect's work. The analysis was not of course scientifically-based or even thoroughly detailed for every activity. It was indeed peculiar to out practice. As it was discussed, used, criticised, adapted and so on, we were enabled to see many areas where centrally devised aids and procedures could be useful. A few activities from different stages will illustrate this:-

Near the outset an activity says "Brief Consultants". We devised a standard thorough procedure brief to give to the specialist consultants in the design team. This defines how the architects intend to obtain design information to suit the programme and within the agreed cost budget. Without this it is hopeless to expect ad hoc teams to work effectively.

During the design stages activities require the team to "Prepare Cost Plan". One of the most difficult aspects of design is cost planning and cost control. If one reads the journals and government publications cost analysis and cost planning techniques appear to be well established in Britain - the gap between Theory and Practice is well-bridged. Yet there are surprisingly large sections of the construction industry who never use them. It seems that even the existence of established bridges across the gap is not enough for many professions. The procedure however was actually effected by showing cost planning on the programme of every project and, when the programmes were drawn up with the teams, introducing the basic techniques.

A typical activity during production drawings stage says "Draw Ceiling Plans at $\frac{1}{4}$" to 1' (1/50) Scale" and the actual number of drawings is quoted. There are in fact activities for each type of drawing. We listed all the types (or content groups) of production drawings and prepared a checklist of items for each.

For the activity "Agree Procedures for Cost and Progress Reporting" to Client during construction we have made standard forms and guidance. This area of an architect's work can be fraught with misunderstanding. By initiating at the appropriate time routine procedures based on the intelligent application of practical experience unnecessary difficulties here are eliminated.

All this is as a natural result of central programming. The co-ordinator's access to all jobs is through programming. In drawing up programmes the special problems and requirements of the particular job become apparent. The service is immediately useful since the co-ordinator identifies these, often before the job teams, in eliciting programming information. He can thus determine requirements for design information for the job and initiate action with the Information Service on behalf of the team. The programme is the key to every co-ordinating function.

Feedback

That the key to co-ordination lies in programming is clearly demonstrated once more in the operation of "feedback". In the typically carefree use of this vogue word by designers the concept of feedback has been narrowed to mean mere appraisal, for example in Section 4.340 of the R.I.B.A. Management Handbook (4). Most Theorists of design method stress the importance of feedback both within the design process and as an essential stage at the completion of designing, whereby the designer systematically sees that he learns from his own experience.

Feedback seen only as the last part of the design process tends to be neglected in practice. In my view the main reason is simply that we are all so very busy and as one job ends we are already waist-deep in the next one. Furthermore it seems difficult for busy practitioners to find time to look hard at their colleagues' work or work going on generally and learn from that. A less charitable reason, given by Professor Markus, is that most designers hold strongly the belief that what is learnt from one project has only faint relevance to the next (7).

These aside however it must surely be evident that few of those who exhort designers to practice "feedback" offer any techniques that can be proved useful to practitioners. The R.I.B.A. Handbook displays an elaborate and apparently systematic technique for appraisal, but I cannot imagine my own colleagues in practice embarking on such exercises voluntarily. Inevitably they would delegate such a function to that universal layabout (because he is not running his own jobs) the co-ordinator.

To quote a recent Building Research Station study: "Despite the paucity of documentation, there is undoubtedly among designers a wealth of information gained from experience, much of it carried in the minds of partners and effectively applied in making strategic decisions" (8). Rather than attempt to improve those minds or give them further work to do the co-ordinator must look for ways to assist them. Therefore I think it is right that feedback functions are delegated to him - but how can he do it?

Feedback differs from appraisal in that it has the purpose of strengthening or modifying the process of which it is a part. Although the experience of a completed process is fed back to a preceding part of the process it is of course being fed forward in time so as to effect the next cycle. Strictly speaking feedback can only apply to a continuing and cyclic process. This is an elementary concept in electrical systems but not so easily applied to the practical work of designers.

What feedback means for us is the recognition of the need systematically to learn from experience and to apply what is learnt to succeeding work. It is the common experience however that feedback in the form of Reports, Appraisals, Design Notes, Office Memoranda, and so on have very little impact on Practice. This coincides with another common experience that most published Research work has little or no impact on Practice either. I began by giving this as one of the symptoms experienced by a design office when it perceives itself to be on the edge of the Gap.

This lack of impact is no index of the value of the "feedback" material or of the research results. The reason for it seems to be much simpler. It is that the so-called feedback occurs at random. If it is timed to occur precisely when it can be used effectively on a particular project the chances are that it will be so used.

Consider for example a Research Report on say Flat Roof Design which might appear tomorrow in a widely read technical journal. The probability of its arrival at the drawing board of a particular project to be of immediate use must be extremely low compared with that of its being either too late or too early in the process. It is a pity if it is too late, of course, but if it is too early one would expect it to be carefully put aside until the right moment. But that may be weeks, months or even years away and we cannot be surprised if by then it has been forgotten and/or lost (or even superseded by further research). A secondary cause of rejection of information is that the practitioner may not have the time or the skill to interpret and adapt the material to his own project's particular needs.

The co-ordinator should have both as I have been trying to show and using his 'key' - the project programmes - he can introduce information (theoretical guidance and feedback) carefully selected and adapted to the project in hand and precisely at the times when it can have an effect.

For these purposes the co-ordinator draws upon an armoury of knowledge, not only from the practice's collective experience but also from the store of published theoretical and research data. Collecting this data is a very important function of the co-ordinator. In using it however he is subjecting it to a fairly severe test which could provide a valuable feedback to the fields of Theory and Research themselves.

This aspect of feedback of course is well-known and research projects to identify practical aids and needs in evaluation are already under way (7). What I want to draw attention to is the way the "feedback" can be put into operation. It is part of the service that design teams receive when they can use it and contribute to when they produce it through a co-ordinator and within a programme.

Alternation and Participation

I have mentioned that one of the problems any co-ordinator must solve is proving his competence at the work his colleagues are doing. Without projects of his own this had to be attempted by attaching all new procedures, techniques or design methods to suitable guinea-pig projects. Naturally the individuals already working on these projects contested the suitability of the particular innovation and only reluctantly agreed to the trials. If subsequently successful the procedures were made a standard routine for the office as a whole. Although this was necessary at the outset I have now modified my views of this approach.

In May 1967 there was an unexpected opportunity for me to take on full-time project responsibility for a unique and technically challenging project. I dropped the role of co-ordinator completely for a period of about 16 months and reverted to running an extremely hectic and fast job. Adjusting suddenly was difficult for me though it did not take me long to adopt the attitudes of a busy project architect with no time for rational design methods and procedures, programming, etc. that as a co-ordinator I deplored and had been dedicated to changing.

Direct confrontation with the problems of Practice was a very stimulating experience after a break of nearly four years. As well as testing the various techniques and procedures already introduced we were able to identify new areas where improved performance was possible and opportunities for devising techniques and aids to better design and smoother operations. Again the psychological aspects of team working, especially with teams from other offices, were seen to be extremely important.

The experience and assurance that the bout of Practice furnished suggests that any organisation with a co-ordinator should seek suitable opportunities to give him alternate experience for limited periods.

At the end of this period I was able to review my original function and see how it could recommence and develop.

This led to another modification of my view of the responsibility of the co-ordinator. The problems of implementation of standard procedures and of persuading more-or-less independent teams to adopt office routines rather than to use half-baked new ones of their own invention had always been difficult to over-come. During the period when I returned to being a project architect I certainly experienced the same attitude to "Co-ordination" when I myself was under the extreme pressures of a fast-moving project.

And so I would now change the emphasis from co-ordination to participation. Our present approach is to provide a Central Service to all design teams in the office. The functions of the Central Service include programming, design information, feedback, the introduction of the best techniques available and the application of research knowledge and being responsible for their proper application within the team. The change is in the acceptance of specific executive functions on each of the jobs. The co-ordinator therefore has to take a part in each design team and in a busy design office this must result in the creation of an adequately staffed Central Service.

If alternate bouts of Practice are desirable for a co-ordinator so are alternate bouts of Research. Again actual experience has quite positively confirmed the value of this. I have indicated when describing our Programming Techniques that drawings are the principal element of detailed programmes. As a result of our interest in drawings I completed during 1970 a series of studies of project drawings. The studies were carefully planned and the data methodically collected and analysed with all the rigour and objectivity I would expect to find in an academic project. I began with a thorough search through published Theory only to find that no systematic research had ever been carried out on what is by far the most important part of an architect's work.

The research proved highly successful within the practice by giving insights into the nature of our day-to-day work and generating further aids and procedures for design teams. It has also aroused wider interest and been published (9) so that we have added a mite to the stock of Theory and this in itself gives encouragement to the general aim of bridging the gap.

It is said that Researchers and Practitioners "do not speak the same language" but the difficulty they experience in not understanding each other arises not from language but from their having quite different professional goals. The Practitioner needs to make decisions, preferably sound ones based on the best available knowledge, but if he can't get this he still has to make his decisions. He tends to find fault with the Research rather than the state of his Practice. The Researcher needs to find out knowledge for its own sake which he expects will prove useful in application but if it is not he will still attempt to solve problems by further research in preference to working with inadequate supporting data. He tends to find fault with the practical situations rather than with the state of Theoretical knowledge.

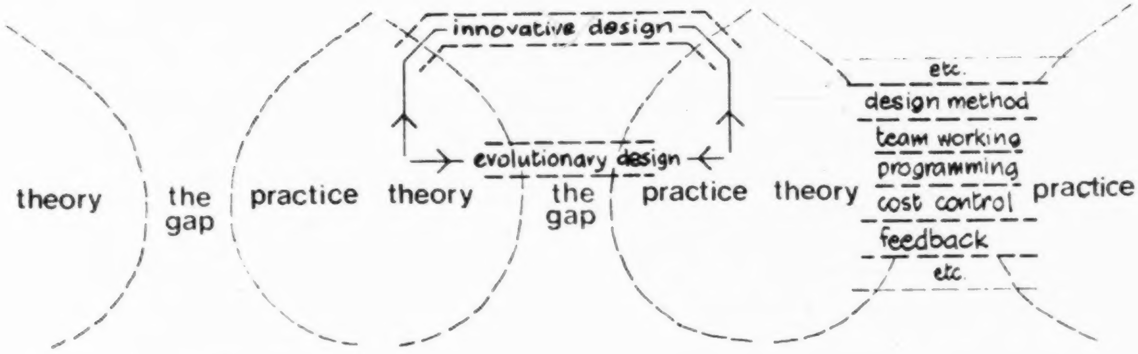

Figure 3. Bridging the Gap

Professor Robert Sommer has observed (10) that psychologists, when they operate as practitioners adopt a different approach to the one they use as scientists. He states that "the need for translating scientific findings into a form usable by practitioners exists in almost every field" and he suggests that "Some middleman is needed." Well, for a professional co-ordinator, this is valuable reassurance.

It is perhaps inevitable that Researchers and Practitioners observing each other across a gap of misunderstanding will tend to sneer at each other's work on occasion. Each has so little experience of the other side. The co-ordinator needs to share the attitudes of both and to be reasonably experienced and competent in both fields, hence the value of his alternating periods of activity in both. He cannot operate unless he can communicate fluently with Researchers and Practitioners despite the constraints of his milieu. I am harboured in Practice, for example, but this does not prohibit research studies altogether and the idea of alternating has proved practicable.

This specification, I am aware, asks for a rare bird, even a suspect one. He has to face both ways with confidence even when he feels at times that he belongs to neither side.

Bridges

Bridging the Gap is a metaphor that an illustration may help to elucidate. We can show Theory and Practice as two areas separated by a gap (Figure 3). The areas are so shaped that a section of the gap between them is relatively narrow but it widens at each end increasingly sharply. Where the gap is narrow it is easiest to form a bridge, but it gets harder progressively quickly as the gap widens, becoming virtually impossible where the boundaries of the two areas, Theory and Practice, do not even face each other.

Christopher Jones has pointed out the important distinction between 'evolutionary' and 'innovative' design (11). In my visualisation of the gap, daring unexpected bridges across the wider sections will be the outcome of the best innovative design, while evolutionary design uses the easier, safer spans for short trips over the narrows.

Traffic between even the remoter boundaries of the two areas is easier therefore via smaller bridges across the narrow part of the gap. What I think we have found is that, having made a bridge where it seemed to be easiest, we make progress, not by starting to build more ambitious and independent bridges across wider parts of the gap, but by keeping the small bridges constantly in use, widening them on both sides and joining them together into still wider ones. For example, the efficient and more or less rational programming of design in practice certainly gives the designer more time for designing. In working smoothly to a programme the designers are considerably relieved from the day-to-day crises and hurried decision-making that characterises practice generally. We are certainly finding this now in our organisation where the Central Co-ordinating Service has a part in each of the teams. They now get fed relevant information precisely when they need it for design decision-making and when it can have due influence on them. At the beginning of a project this includes up-to-date research material which it is the job of the co-ordinator to be aware of. It can also include personal contacts with research workers and visits to designs under construction or recently finished from which the designers of a new project can learn (feedback). Above all time and skill are available for adapting the results of research to practical purposes.

Both in this way and through the powerful medium of the job programme design methods can be affected. Again programming is central to the achievement of this as of other objectives.

Through it, time can be made available for the "creative" parts of the design process when it is most needed, and techniques to expand this process as much as possible can be supplied to the drawing board.

When designers are pressed to give reasons for inadequacies in designs, the commonest is that there was not time to do anything else. The second commonest reason given is that for this particular inadequacy the designer had no control, i.e. the client or the consultants or the exigencies of production forced the architect to acquiesce in a particular decision against his own judgment or preference. Lack of money is also commonly blamed although with the increasing publication of cost analyses for buildings it is a less easy excuse to sustain. Here, too, the smooth programming of large and diffused teams can give the architect the opportunity for greater control. In other words he can anticipate those areas where he may be forced into unsatisfactory decisions and concentrate on correcting this. This first small bridge across the Gap has given the practitioners wider opportunities for improving their practice. It must, of course, be up to them to exploit the opportunities.

Implicit in this model of the situation is a criticism of the extremes of Theory and Practice and a firm commitment to gaining the command of the middle ground and only exploring outwards from there. This is the inevitable result of my particular experiences.

I have said elsewhere that designing is a *human* activity (12) and because of this it follows that *human values* are the ones that should be used for assessing its results. Extremes of Theory about what should be done, or of blind or mindless Practice in doing it, inevitably score low in such assessments.

In 1966 Geoffrey Broadbent called for the commencement "of a dialogue between educationists and practitioners" (13). He made a strong plea for it again at an informal conference of the Design Research Society where I see that I was "worried about bridging the gap between theory and practice" (14). Certainly it was about this time - I had been a co-ordinator for three years - that I first saw my work in these terms. From the point of view of architectural designers that conference was very stimulating. Systematic Design Methods had been available for some time but there was little evidence of their use. D.G. Thornley whose method was one of the earliest published (1) said that he had progressed from using it in teaching to applying it in a small practice but admitted that they had been defeated in their first attempt to go beyond that inside a large high-powered architectural practice.

Another architect researcher and educationist, Peter Manning, has more recently complained that "the gap between research and its application in practice is too wide; the problems of communication and *implementation* (my italics) are among the greatest we have" (15).

I have attempted here to describe some of the features of 'implementation' or bridging the gap and I would like to reinforce Broadbent's urge for Practice and Theory to begin a dialogue.

If I can sum up at all it can only be with a series of questions, which have arisen from my particular experience. How important is the psychological element in Bridging the Gap between Theory and Practice? Does its importance have new implications for the selection and training of designers? To what extent is design education the reason for the existence of the gap between Research and Practice in the first place? To what extent is the co-ordinator necessary in design organisations? Does it depend on their size? How can very small design offices or solo designers succeed in Bridging the Gap? Must this service be tailored specially for each design organisation or is it feasible for whole sections of the profession? Will recent developments (CI/SfB, the R.I.B.A. Plan of Work, the Metric System and Dimensional Co-ordination, the services of a range of computer programmes and of management consultants with experience in the building industry etc) prove useful without the need for co-ordinators within design offices? If not, and if they are not helping to Bridge the Gap, what is their value? How much research effort is wasted as a direct result of the gap between Researchers and Practices?

There are surely many with experience to contribute in answering all these questions. If so, a public dialogue will make their experiences useful to everyone. If the answers are not simple the value of a dialogue will be in showing how much work in this field is already being done and how much more there will be to do.

Acknowledgment

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A DOUGHNUT MODEL OF THE ENVIRONMENT AND ITS DESIGN

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1 Introduction

Systems thought has been deeply influential in planning and architectural theory in recent years. Systemic models of cities, buildings, transportation networks, engineering services, building processes and design processes abound. It is a commonplace that for any such model to be reasonably useful — i.e., to represent and interpret the real world in a way which has some predictive power — the sub-systems and parts of the model must be properly related to each other. To be related there must be some consistency of definitions, units, concepts and dimensions.

It is quite clear that such consistency is almost totally lacking in the various models which, between them, are supposed to represent what has come to be called the built environment. Some models describe concrete objects in physical terms. Others describe energy systems as thermodynamic systems. Others describe the people who use the systems in behavioural psychological terms and the process by which the systems are designed and built in highly abstract decision-making and production-flow terms. This paper attempts to describe buildings, their environments, their users, their designers and the total resources which go into their design, construction and continuing use as parts of a single system. It shows that such a model has important social and political implications.

2 The System

The system here described is basically derived from the model developed by BPRU(1971)(1). This system is considered to consist of people and things, interacting in a complex way. The "things" specifically of interest are those pieces of hardware which generate the environment. People are assumed to be goal oriented — seeking to achieve objectives of an idealised kind by achieving more immediate goals. One of the goals which people clearly wish to achieve is a good state of the environment — that is one which is helpful in achieving all their other personal, social and organisational goals and objectives. The system includes certain resources of energy, skill, material and time available for the achievement of its goals.

The system can exist at any scale; for instance a city region, a town, a building or a single space within a building. At any level a system of a smaller scale can be seen as a sub-system or component. The model described below could be developed for any scale, but the empirical research upon which it is based was carried out at the scale of a single complete building and its users. The users were assumed to be members of an organisation and therefore the description of some of the elements in the model was influenced by organisation theory.

The system has five main parts:

(a) The objectives system
(b) The activities system
(c) The environmental system
(d) The building system
(e) The resources system

It is diagrammatically shown in Figure 1. These five, with their sub-systems and components, make a complex system which is of course open; to influence of politics and economics; culture; climate; city plan and the site; the social and business context. It is within these that the building universe exists — and it is only to make discussion easier that the model described below is explained in terms which isolate this system from the larger universe.

2.1 The Objectives System

It is assumed that individuals are goal oriented in order to achieve objectives and as a consequence it is necessary to consider some of the goals as part of the objectives system. The objectives system consists of those long term aims for which the

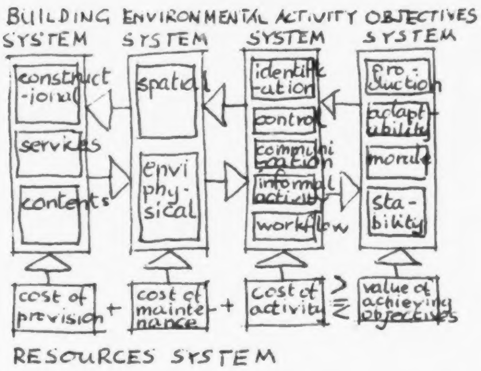

Figure 1
The Building/Environment/Activity/Objectives/ Resources System

organisation exists. These objectives provide the context for all the activities and hence for the buildings and environment. Often an organisation's objective is in conflict with broader, social objectives (e.g., industry and pollution) or with narrower personal ones (e.g., production and friendship formation). Such micro and macro conflicts are inherent in all organisations and the designer has to understand them and adopt priorities. Often his own objectives will cause further conflict.

Whilst we are still a long way from being able to specify exactly the objectives of many organisations and isolating those for which the environmental system is particularly relevant, there are four general objectives common to most organisations which are likely to be of relevance to the design process.

(i) Production. The great majority of organisations change some resource from one level to another; they create a product. In industry this is obvious; however, the implications of the production objectives are not so obvious in so-called non-commercial organisations of which schools, hospitals and houses are examples and as a consequence the more obvious building implications for that productivity are sometimes missed.

(ii) Adaptability. A slightly less obvious organisational objective is that of being able to adapt. Survival is based upon a two way process of adaptation and for an organisation the ability to change itself in response to changes in the environment is a crucial one. As with other organisms it is likely that also with organisations some of the most crucial limitations on adaptation are set by physical structure.

(iii) Morale. It seems reasonable to suggest that many organisations have as a distinct objective the wish to keep their members happy. With such non-commercial organisations as clubs this is obviously the case but many industries also claim this as an aim in its own right without the ulterior motive of increasing production.

(iv) Stability. The turmoil and constant variation which the above three objectives either create or deal with, inevitably give rise to difficulties within the organisation in terms of its stability or the degree to which it exists as a single entity over time and space. As a consequence a further organisational objective will be to maintain the organisation in a stable state so that although production is being maintained or increased, adaptation is taking place and morale is also maintained, the organisation continues to exist in a recognisable form.

These four sub-systems of the objectives system all interact in a variety of ways, this being one of the reasons why they can be regarded together as a system, and between them and their interactions most of the overall objectives of most organisations can be accounted for. In many organisations these require a building or a specific type of environment if the organisation is to move towards achieving them, so it is valid to think of this system giving rise to the need for the further system of the building. On the other hand, the reason for the building is that it generates an environment required for the activities needed by the organisation to achieve its objectives. In other words, the objectives give rise to the activities which it is necessary to implement in order to achieve those objectives. Thus the activity system may be regarded as a set of goals, the achievement of which leads to the reaching of objectives. Objectives are therefore the beginning and the end of the whole system; its vital centre.

2.2 The Activities System

If an organisation is described it is usually in terms of what it does; the activities it undertakes; the behaviour in which its members partake. The potential range of these activities is as wide as the range of human potential for action and the way in which these activities are classified depends on the particular aim of the classifier. The purpose at present is to describe as simply and as briefly as possible the range of activities for which the building and its environment are relevant. Five categories are used. These categories do not contribute in a direct way to each of the objectives but rather the objectives are achieved as a product of their interactions.

(i) Workflow. One of the activities central to most organisations is that associated with modification of resources to give rise to a commodity of greater value. This workflow activity is usually considered the essence of an organisation. A factory is described as 'making cars', for example, and so on. Many organisation and method studies concern themselves solely with the improvement of workflow activities as these are often the most obvious determinants of organisational success.

One productive process which is required is the construction of environmental hardware — building. Like other specialised processes, for instance catering or laundering, or making machines, this task is frequently contracted to an independent porducer.

(ii) Control. In order to keep the workflow activities continuing smoothly, helped by all the ancillary organisational activities, fed with the right materials and relieved of products at the correct time it is necessary for some parts of the organisation to be responsible for coordination and control of the whole activity system.

Of course, control does not relate only to workflow activities; as organisations become more complex so more energy is spent upon controlling the other aspects of activity. In fact one of the critical growth points of an organisation may be thought of as that point at which it needs to instate processes that are specifically geared to controlling existing control processes, in other words, when a division between senior and junior management takes place. This is no place to discuss the subtleties of this process but it should now be apparent that the relationship between control processes and the other processes which make up an organisation is often critical to the survival of that organisation.

One important goal which any organisation has to achieve is the control of its own environment. This involves the continuous adaptation of space, site and services for full use; planning for replacement, obsolescence and repair; re-organisation of activities in accordance with physical constraints. This activity, in complex situations, is now a specialised form of control commonly called design.

(iii) Communication. It is not possible to think of the organisation as a static thing. Even to continue to exist at one level it must take in resources and modify them and dispose of those which it cannot assimilate. Many organisations are constantly developing and changing. It is of the essence of organisations that some of their energies are spent transmitting resources, products or phenomena from one place to another. This process of transmission from place to place may be taken as an inevitable counterpart to the process of change from one state to another. The transmission aspect of the activities are referred to as communication.

Communication is taken to include, in most organisations, the movement of people, things, energy, and information. From the two aspects mentioned above it will be clear that the movement of resources through the workflow process involves communication and that the transmission of instructions from control to workflow centres also involves communication; but so will all the other aspects of activity.

(iv) Identification. When communication takes place it consists of transmission of something (or someone) from place A to place B. That much is obvious. What is not so obvious is that it must be possible to identify B as B if communication is to reach the destination for which it was intended. The very essence of the distinction between place A and B is that they have separate, distinguishable identities. If there is any choice at all in the route which the communication can take when it leaves A then the identification of B becomes critical in determining whether the communication gets there. If there is no choice in the route from A to B then in what sense is it meaningful to think of them as separate entities?

We tend to think of identity (specially of people) as something which is part of an object (or person) and which makes it unique. However, in many cases it would seem that a more fruitful way of thinking of identity is as those aspects of the object in question which indicate how it interacts with the other objects in the system of which it is a part. The identity of an object thus relates to its role in a particular system. If the system changes so does its identity.

Out of all this grows the need for an organisation to devote some of its energies to specifying and maintaining the identities of its component parts although in many cases these energies will not contribute directly to the workflow.

Finally it should be pointed out that just as the parts of an organisation must be identified if they are to function adequately, so organisations must have appropriate identities if they are to function in the larger system of which society consists.

(v) Informal Activity. Not everything which goes on within an organisation is part of the four processes described above and not everything which takes place is directly a part of formally organised activities, or under the control of the 'controllers'. Therefore, a complete description of the activities which an organisation needs to achieve its goals must include a category for this informal activity. The simplest way of thinking of this category is as a miscellaneous one, the size of which is directly related to the sophistication of the organisation or our knowledge of it. This category might also be thought of as containing activities which the organisation needed to deal with its own inadequacies — slack introduced into the system in case the strain grows. This latter possibility seems the more plausible on the basis of a model of people as goal oriented. If they are goal oriented it is probable that they have personal goals in conflict with those of the formal organisation. Achievement of these personal goals may well be essential for morale, however, and slack in the system may serve to make them possible by informal activity.

One description of informal activities, then, might be those activities brought about by a miss-match between the goals of an individual and the goals of the organisation of which he is a part. In allowing individuals to find ways of satisfying their own goals within the organisation they are in fact being encouraged to continue as members of the organisation. A further point worth considering is that an organisation develops within the context of a particular economic, social and political climate and as a consequence might not have built into it the possibility for coping with changes in that climate. However, individuals are not tied in quite the same way and hence their informal activities can contribute considerably to the organisation's ability to adapt to change.

This means that provision for informal activities will enable the goals of individuals and of society to be achieved. It raises the whole question of the designer's responsibility for, and openness to, values and goals other than those with which he is formally presented. It is also relevant to ask to what extent deliberate planning and provision for informal activities by authorities is a self-defeating process.

2.3 The Environment/Activity/Interface

If it is to function properly, any activity system must have an appropriate environment. In most cases this appropriate environment is provided in buildings, which modify the external environment in various ways and provide a controlled, internal environmental system within which the activity system can flourish. The relationship between these two systems is particularly intricate and the elucidation of this relationship is central to the development of an understanding of building and environmental design.

People are active and consequently they modify their environment in order to change the way it affects them. This mutual interaction goes on constantly, and it means that it is incomplete to consider an environment without an activity taking place within it or vice versa.

2.4 The Environmental System

The environmental system is required to facilitate the activity system. Different activities require different environmental levels and different ranges of adjustment; these are found within different buildings and within different parts of the same building. It is important to distinguish between buildings and the environmental systems they provide because two similar buildings can produce quite different environments. Organisations build not because they need to build but becuase they require a particular set of environmental conditions for their activities. These conditions must be variable within the limits required by the people carrying out the activities and, of course, they must control unwanted variations in the external environment. People modify their environment according to their activities, sometimes deliberately by adjusting or making alterations, as when they switch on lights, sometimes accidentally or at least unwillingly, as when electric light increases the heat level.

Categoric distinction between the sub-systems of the environmental system is difficult because of their highly interactive nature, but two recognisable sub-systems clearly emerge.

(i) The Physical Environment. Those aspects of the environmental system directly perceived by the senses: heat, light, sound, texture and smell.

(ii) The Spatial Environment. Those aspects of the environment related to the dimensional and geometrical properties of single spaces and to the spatial relationships between them.

These two are very broad categories; but it is clear that interactions with activity is high. For example, noise and light affect work output and communication; people continuously adjust, extend, re-arrange their spatial environments.

(iii) Visual Environment. One characteristic of environment is of exceptional importance and straddles both sub-systems. It is the visual quality of spaces seen in light. This is central to the art and practice of architecture and is the vehicle whereby meaningful experience is obtained from form. In the design of the building system many choices are made for the sake of this characteristic. Its experience is aesthetic experience, one of the human goals motivating the activity system even though the production of satisfactory aesthetic experience may not be explicit as an organisational objective. It is all pervasive, throughout the system.

2.5 The Building System

In order to achieve its objectives an organisation requires a certain environment and to achieve this environment it produces a building. The stuff of which the building is made, the bricks-and-mortar, components, service installations and so on, comprise the building system. It includes all those items normally described in drawings, specifications and bills of quantities and all tangible contents other than human occupants.

The building system gives rise to the environmental system by modifying the external conditions, and this modification is done in two distinct ways. Firstly, by exclusion, or filtering or selectively admitting through the fabric and secondly by consuming energy to generate an environmental condition.

Three sub-systems of the building system can be readily described.

(i) The Constructional Sub-system
Within this are categorised not only the structure, be it frame, shell or whatever, but all the inert, not directly energy consuming, constructional parts of the building fabric.

(ii) The Services Sub-system. The service installations concerned with the supply and disposal of water, gas, electricity and fluids and solids for use in the activity system or in the modification of environmental conditions.

(iii) The Contents Sub-system. Plant and equipment, furnishings, fittings and finishes. Precise definition of the distinction between the previous two sub-systems and this last is difficult, and perhaps the best working definition is that the contents system comprises all the 'hardware' of the building system not included in the two previous sub-systems.

2.6 The Resources System

Each of the four systems described above has an initial and/or continuing cost or value. The building system costs something to provide. The environmental system has costs of energy maintenance, cleaning, etc., associated with the maintenance of any given environmental state. The activities consume resources — wages and salaries, materials (used and wasted); advertising; recruiting; image-making etc. The objectives have values; these values should exceed the combined cost of the first three systems — otherwise the system is running "at a loss". The difficulty of quantifying values in cash, or other units commensurate with costs, should not blind one to the need for, and possibilities of, adopting cost-benefit analyses for many design problems.

3 Design as a Basic Human Activity

The activity of design is a purposeful, goal-oriented search. The search is for a physical solution to a perceived and, more or less, understood problem. People have perceived such problems from the earliest times. Sometimes survival depends upon a successful outcome to this search — say a search for safe shelter. Often the problems are only dimly perceived; sometimes they consist of a whole group of related problems whose complexity is hidden by the apparent simplicity or unitary nature of the solution. Always the search has to be successful within certain constraints; time (before the cold weather); energy (not too far; or not too heavy for two men to lift); skill (capable of execution by a limited technology); money (purchasable with the available funds).

Human development has often been described in terms of design and technical ability and periods are conveniently labelled according to the technology adopted in them. Thus design can be regarded as a fundamental human activity requiring both consciousness and thought to understand the environment; will and purpose to control, change or improve it; abstract thought to imagine changed states of the environment in anticipation; and skill to bring intentions and plans to concrete realisation.

So, more formally, one might define design activity as: action aimed at finding solutions to perceived problems within a resource envelope. However, since such a definition covers any action aimed at solving problems, even where the solutions are decisions related to personal or organisational behaviour, say a decision to fight a battle; or to understanding a set of mathematical equations, a further refinement of the definition is needed. For the purpose of environmental design in general, the solution in part, at least, must consist of physical systems — some hardware. This hardware affects environment and thus the lives of individuals and organisations existing in this environment. It is part of an interactive animate/inanimate system described earlier. One might also usefully add that further, productive action results from decisions about these hardware systems.

In Section 2 a model was proposed which relates in one integrated system, people, things and people's resources. In the past, designers' descriptions of buildings have generally been in hardware or environmental terms, and the effect of these on people has had to be described by inventing a special species of people called "users". Their goals have been called "user needs" and much fruitless survey work has resulted from the lack of an empirical model which related things and people.

Behavioural scientists, on the other hand, have traditionally regarded the variables of physical environment as intervening nuisances which have either been held constant or, more often, ignored. Professional designers forgot that it was only recently that the magnitude of design problems has caused them to be employed to carry out what has always been a communal activity; and behavioural scientists have overlooked a tremendously rich field of observable action which contained information on values, imagery, social networks and concepts.

3.1 Control and Workflow

The interactive systems model described earlier contained, as one characteristic organisational activity, control; the kind of generative, organising acts which relate all other activity towards objectives and goals. Organisational theory has generally seen control as being concerned with other activities — "design of activity patterns" might be a useful description. But one important aspect of control is the control of productive activities (workflow) for the creation or continuous re-creation of environments best matched for human purposes. The outcome of such productive activities are new or changed products — pieces of hardware (buildings, say). Another activity shown in the model is workflow; that is, productive activity. The production of buildings and other environmental hardware is just as much part of the workflow process as design is of the control process. It is similar in another respect too; that is that it is often delegated to a specialist production unit — e.g., a contractor. So design and production of hardware is part and parcel of the systems model. And the achievement of the best state of the whole system represented by the model can be seen to be an ever-present objective.

An important part of the whole system is the resources system and to say that the best state of the whole system is an objective, is another way of saying that the best allocation of resources in that whole system is an objective.

Thus we have inside the system two activity sub-systems — building design and production — whose objective is a state of the whole system. Design is a generative sub-system which enables the larger system to exist, change and remain whole. The paradox of a sub-system being the generator of the system of which it forms a part — being inside as well as outside it — is conceptually similar to certain topological problems in mathematics in which surfacesof holes in objects continue to envelope the entire object (the hole in the doughnut).

For confirmation that design and production of environments are present in most social or organisational systems, one has only to look at a few examples. Individuals, families and tribes, design and build their furniture, houses and settlements. When the problem concerns complex organisations and technology a simple discussion between the parties (say parents in a family) and production by "do-it-yourself" may not suffice. Although in some primitive communities design of dwellings and settlements is still a public act, done by the community and for the community, specialised designers and producers are usually employed today.

3.2 Power and Design

What effect has this professional role of designers, and specialist role of building producers, outside the community which becomes the end-user of the created environments? The simplest answer is that environmental control — design — has become as much part of authoritarian and bureaucratic processes as all the other activities controlled by the "controllers". This control group hires and fires in-house or independent professional designers who will give them the environments which best suit the organisation's purposes. Certainly some built-in design freedom is tolerated in the system — as part of "informal activity". A student may put pin-ups on his study/bedroom wall; a tenant select his own curtain material or front-door colour.

At a subtler level it has become clear that if design is, indeed, such a potent part of the whole system, conflicts about who designs, and what is designed are likely to be amongst the first issues in many revolutionary movements. The destruction of property in riots, and vandalism, can be seen as negative production. The taking over of buildings, their re-use for emergency purposes and ultimately their re-design has always been necessary when power shifted. The polarity between authority and individuals or groups can be seen in environmental conflicts of many kinds:

(1) Organisations value a concrete image; unified, purposeful, concentrated. Individuals often value a more ambiguous, diffuse and varied environment (e.g., workers in shirt sleeves and braces were seen as violating the modern and neat image of the C.I.S. offices in Manchester.).

(2) Organisations generally oppose ad hoc environmental adaptations by their members.

(3) Subversive organisations generally work without formally dedicated environments; when the Christian Church or the Communist Party adopted such formal power symbols their revolutionary message was already waning.

(4) The control of expenditure on building is always separated from other resources — housing cost yardsticks; pupil-place costs; cost/bed of hospitals. All attempts to include these resources with, say, costs of wages or materials are strenuously resisted.

3.3 The Possible Roles of Designers

It would appear, then, that design, as a generative and potent sub-system of all human activities, can initiate wide-ranging social and political change. Western style democracies have realised this and there has been an immense flow of resources into research and development into planning "participation", user-need studies; public enquiry systems; advocacy planning; participatory design — these are but a few of the activities which have come about in response to genuine democratic pressures. The literature suggests, however, that they are examples of Schon's "dynamic conservatism"; ways of appearing to change but actually staying still. Appeals to the national interest, to the expertise of the planners and designers and to long-term benefits have been used to justify environmental inequities of the grossest kind. Many planners and architects have felt themselves to be in the vanguard of liberal reform but have not faced the fact that they mostly have to be employed by authorities who will ultimately resist any re-allocation of power.

They have, now, three main alternatives:

(1) To continue and increase emphasis on professionalism of a kind which is based on "expert" and "inspirational" roles. Such a role depends on stable social structures, material and social recognition of design skills, together with the full system of legal protections. Such a designer, whilst protesting his independence of political pressures, can only function by public or private patronage from the centres of power. Broadly, he is a conservative.

(2) To adopt a sympathetic stance to so-called "participatory" design processes. Such a designer is likely to accept the growth of his professional body to include new disciplines and educational backgrounds. He will work less as a value-judge and be concerned to make the design process more transparent. He will readily adopt design games, computers, public simulations etc., as means of developing ranges of possibilities for public choice. Whilst this range is still his decision, it is likely that solutions will emerge which effect some compromise between authorities and planners on the one hand and the planned on the other. Such a designer is generally from a middle-class leftish background — he rarely comes from the communities for which he works nor lives in them. Broadly, he is a liberal reformer and is likely to have a self immage as a democratic community leader.

(3) To reject both above solutions and work for a real transfer of power on design decisions. Such a designer will seek employment by clients who will be end-users; but generally will find his work will have to be voluntary as such groups control no environmental resources (e.g., tenants in twilight housing; factory workers; hospital patients). He will see his role as one who has powers of discerning the latent solutions already existing in the patterns of life and values of his clients. These he will try to develop, but his expertise will be more that of a midwife. He will generally reject participation in this process, as he may claim that this is

a) too sensitive a matter to be capable of resolution by crude group processes, and

b) a technique of political manipulation.

He will be much concerned with the language and concept barrier (cf Bernstein) which separates him from the majority of the population. He will try to live in his work-environment. Broadly, he is a revolutionary.

Of course there is a whole spectrum and not three categories. But the key to where a designer lies along this spectrum is his view of the relationship between environmental control and all other control in the system.

3.4 Models of Design

Many models of design have been produced in the last 15 years. None of these, so far, has started off with the social and political status of the designer and hence all have failed to relate the design systems they represent to other social and political actions. Not surprisingly, since real design is a socially significant and, largely, socially controlled, activity, these models have failed to convince designers of their realism or significance. Systematic design conferences and discussions have become fragmented by a relatively esoteric, small group, too often "eunuchs" in terms of design experience. Refinements of these models — in terms of feedback loops, spirals, trees, networks etc., are, of course, important. But they cannot succeed in adequately describing design unless they are rooted in careful social analysis; even less can they hope to be formative in educating a new generation of designers.

3.5 Continuous Design and Production
Initial design and continuous re-design are not categorically different activities. The main difference is that in the former only half the system — objectives and actual or proposed activities are present — the necessary environmental hardware comes into being in conceptual, abstract, form which can be modelled; whereas in the latter, a whole system exists although alterations to it still have to be modelled before being produced. Today professional designers are employed for the former but not, usually, for the latter; this does not mean that continuous design and production of hardware does not go on. Studies amply demonstrate that they do. If the initial designer has done his work well he will leave behind:

a) a hardware system which is capable of being adapted (i.e., robust), and
b) a design or decision-making technique which is not only sensitive to the feedback inputs and capable of continuously good solutions, but have built into it monitoring devices about the design technique itself and a structure capable of sensing and meeting demands for change in this technique.

Figure 2 shows the system model extended in a third dimension, that of time. A cross section through this solid shows a fixed "snapshot", at any moment in time, of the whole system, which is dynamic. The generative sub-system of design ("control") is the connecting link between these layers, which determines the way one changes into the next. The whole of this solid is concerned with the birth, life and death of one scale of system — say a building and its occupants. Above it are solids of greater scale, below it those of smaller scale and all around it similar ones.

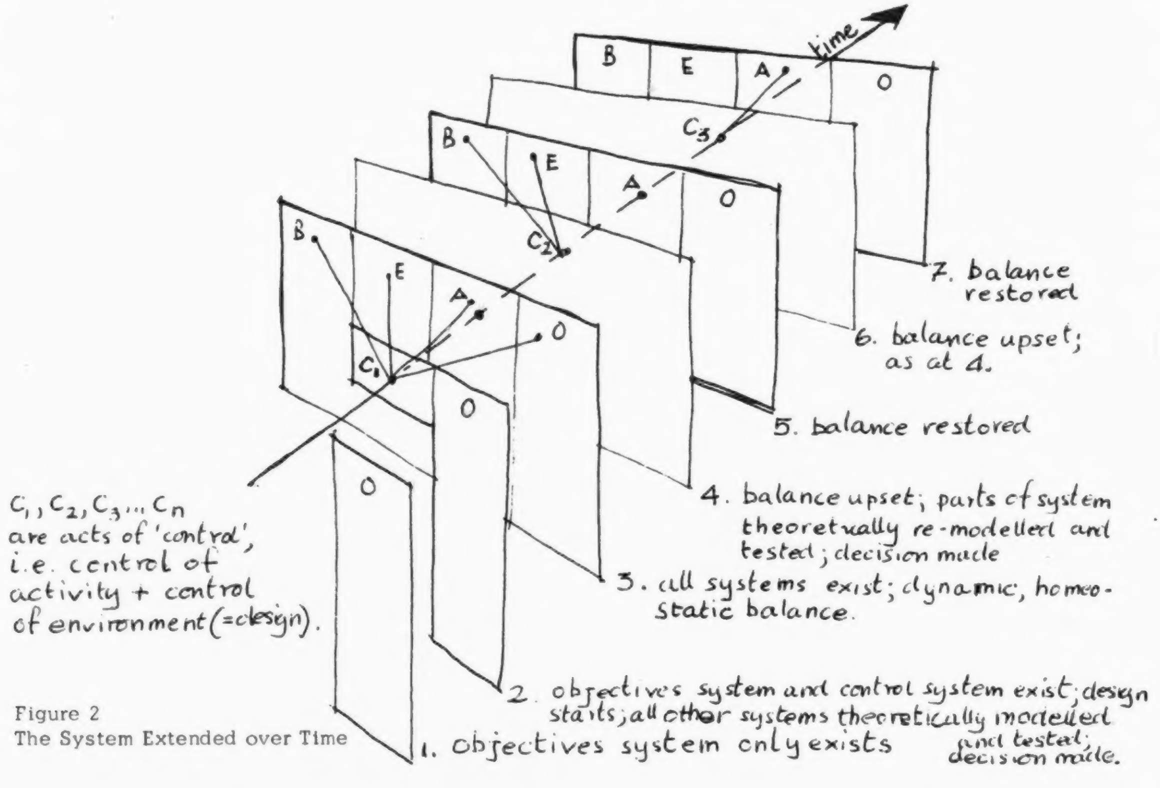
time
B
E
A
O
C_3
B
E
A
O
C_2
B
E
A
O
C_1
O
O
7. balance restored
6. balance upset; as at 4.
5. balance restored
4. balance upset; parts of system theoretually re-modelled and tested; decision made
3. all systems exist; dynamic, homeo-static balance.
2. objectives system and control system exist; design starts; all other systems theoretically modelled and tested; decision made.
1. objectives system only exists
$C_1, C_2, C_3 \ldots C_n$ are acts of 'control', i.e. control of activity + control of environment (=design).

Figure 2
The System Extended over Time

This continuing nature of design and production makes it unnecessary to distinguish too carefully between initial and re-design processes. The initial design of any part of this system can be seen as re-design of the system at the level above. Thus a new building in a city is merely an alteration to the city's fabric. A new room, to the fabric of the building; a new window, to the fabric of the room, and so on. City planners, architects, component designers are each part of a continuous, dynamic design process. "Start" and "finish" are arbitrary operational terms which make designers' labour measureable, but no more.

What now emerges is a generative sub-system which becomes a genuine means of political power. It enables personal and local interests to be reconciled with national and regional ones at a level of *ends* — quality of life, which removes much of the need for experts at the conflict stage; once resolved, experts are needed to bring the decision into being.

Computers, simulations, new communication media and all the rest may enable us to return to a more primitive *form* of community design control whilst achieving results which primitive technology and society could never approach.

Acknowledgements

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Notes

1. Building Performance Research Unit: "Measurement and Appraisal of Building Performance", *Architects" Journal*, 20.12.67, pp 1565-1566; and Markus, T.A.: "The Role of Building Performance Measurement and Appraisal in Design Method", *Architects' Journal*, 20.12.67, pp 1567-1573.

30: SYMPOSIUM ON CONCEPTUAL ISSUES IN ENVIRONMENTAL COGNITION RESEARCH

CONCEPTUAL ISSUES IN THE STUDY OF ENVIRONMENTAL COGNITION: AN INTRODUCTION

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The subject matter of this Symposium is a critical examination of some of the major directions in current environmental cognition theory and research.

"Environmental cognition" refers to the individual's or group's knowledge of the environment. Within environmental behavior, research has concentrated on the individual's knowledge of the structure of the large-scale physical environment, leaving behind questions of group images, the social and emotional environment, and knowledge of function and meaning. Thus we have the seminal work of Lynch on the image of the structure of cities (1), the more recnt work of Golledge, Cox and Zannaras on the individual's knowledge of the spatial location of major social phenomena (2), Downs' work on conceptions of urban shopping centers (3), Lee's and Lowrey's on conceptual distances (4), Appleyard's on images of the structure of new cities (5), and Stea's on general models for studying "conceptual space" (6).

Some people who identify at least partially with this school have done research on other questions. Thus we have Orleans' research on group conceptions of the city (7), and Buttimer's and the more recent suggestions of Gerson on social influences on cognition (8). We have also seen the developmental work of Stea, Blaut, and their students, most notably Hart, Wood, and Mark (9).

Also, work has come from sociologists interested in the total, holistic fabric of the structure, function, and meaning of urban and non-urban environments. Thus we have Strauss's two books on images of the American city (10), Firey's work on urban symbolism and its effects on urban political decision making(11). This work has influenced the more recent interest in "popular imagery" (12). In this vein, though perhaps more influenced by Lynch's beginnings, we have seen the work by urban planners on images of specific cities (13). Also related, but with emphasis on geographical regions and landscapes, is the work by geographers, beginning with the programmatic statements of Wright (14) and continuing to the more recent work of Lowenthal (15).

A third direction has spawned research on images of both generalized and specific environments derived from historical and literary sources. Thus, as two examples, we have Marx on technology and the pastoral ideal (16) and Smith on the symbolic and mythical quality of the American west (17). We also have the current EDRA III papers by Donaldson, Gleason, and Handlin, and the conceptual overview of Seamon (18).

A fourth direction is from developmental psychology, where the interest has been in more spatially delimited questions, such as the development of fundamental concepts of space. Thus we have the pioneering work of Piaget (19) and the work of Bruner and his associates on modes of representation (20). Rand's study of spatial schemas of young children came from this direction (21), as has our own recent beginnings, and, to some extent, the work of Stea (22).

We have also seen in psychology a resurgence of interest in more general matters of the formation of images. Though seldom directed specifically to images of the environment, this work discusses the overall psychological process involved in the construction of images, symbols, and representations in all domains (23).

Although this pigeon-holing may not stand up to careful scrutiny (indeed, if we are flexible and growing, no pigeon-holing should stand for long), it may suggest some of the directions in environmental cognition.

But why the great interest in knowledge about space and the environment? The reason lies much deeper than the current environmental concern. Space is, together with time, the framework for all knowledge. It is, as Harvey has argued (24), the framework for all geographical data. Space is also the stuff around which architecture and urban planning revolve. Within environmental behavior, Beck has argued that space is "a cornerstone of investigations of interactions between humans and their physical environments"(25). On a more fundamental level, Gibson has suggested that to understand human behavior, "space perception is ... (the) furst problem to consider, without a solution for which the other problems remain unclear"(26). Environmental cogniton may yet be seen to be even more fundamental, as interpretations from other perceptual theorists would suggest (27).

The above may also suggest something about the relevance of ideas in neighboring fields, for example: concept formation and symbol formation in the psychology of cognition, impression formation and person perception in social-psychology and sociology, holistic approaches to urban theory and reference group theory in sociology, cognitive anthropology, historical geosophy in geography, neurophysiological bases of spatial thought, and so on.

Purpose and Organization of this Symposium

The aim of this Symposium is to explore current research in environmental cognition with an eye to lurking conceptual issues, to explore various lines of research and the types of questions and theories generated therein, and to bring insights to bear from other neighboring disciplines.

The idea for having such a session rose from many sources. While doing a review of the literature on the development of spatial cognition, Roger Hart and I realized how much research exists on environmental cognition, yet how little theory has been generated. Several people at EDRA II concurred, among them Roger Downs, David Stea, and Jack Wohlwill; the same sentiment was expressed by Kevin Cox at the AAG meetings in Boston last spring. Discussions at Clark involving among others Jim Blaut, David Stea, Ken Craik, David Lowenthal, Bob Beck, and Bernard Kaplan have raised numerous conceptual questions which are perhaps more basic than any specific, delimited concrete data-gathering. The people participating in this gathering agreed to the idea of getting our heads and ideas together becaus, as one person put it, "the time has come for some close work on the theoretical side." Thus a range of people were invited to present working papers on their theoretical positions, and this session was launched.

One notion here, following Pepper, Kuhn, and other philosophers and historians of science (28), is that there exixts in any concrete empirical investigation a whole raft of underlying presuppositions, theoretical notions, and the like. These notions may be ecclectic, scattered, or even internally contradictory, or they may be unified into a testable theory, related to other general theories, or derived from the scientific paradigms or world views of our times. They may be explicitly stated, tested, modified, etc., or they may be implicit, beneath the surface, ignored, denied. Eccliectic or unified, explicit or implicit, they exist, and effect the types of research each of us chooses to conduct, the types of methods selected, the types of findings sought, and the types of interpretations and explanations invoked. There seems to be no way to directly prove or disprove any of these world views, i.e., in most cases there is no one critical experiment. However, through the weight of considerable evidence images are solidified, assumptions are ingrained, world views are organized, and paradigms are corroborated, or, on the other hand, through the weight of considerable counter-evidence images are altered, assumptions are changed, world views are reorganized, and paradigms are rejected.

This is the business we wish to initiate. Luckily, we have a number of people who come from different directions, both in terms of specific training (architecture and urban planning, psychology, geography, sociology, anthropology, systems analysis, psycophysics, neurophysiology, history, and literature) and in terms of philosophical/epistemological positions (quantifiers and humanists, realists and idealists, mechanists and organicists, structuralists and positivists, dispersivists and integrationists, and so on for other 'ists and 'isms). I won't be so bold or so naieve as to try to match underlying assumptions or explanatory theories with the work of the contributors and other participants in this Symposium--that's what each of us is responsible for.

The purpose, therefore, is to meet in an informal yet fairly intensive working session primarily for our own benefit to air, listen to, and understand each other's point of view with regard to these conceptual issues, and, hopefully, to move toward some syntheses. To aid us in this process, position statements and examples of specific empirical projects have been circulated ahead of time. Assuming we have read the submitted papers, the session time can be spent on delving beneath the surface, perhaps stimulated by a short (e.g. 10 minute) summary by each contributor, and prodded by issues raised by each discussant which seem to cross-cut all or a sizable subset of the positions. The discussant's role is very important; we will look to them to uncover issues which we have perhaps been too close to see.

In addition, it will be especially rewarding to personally meet and get to know each other as people in ways not possible through our writings.

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ADAPTATION, STRUCTURE, AND KNOWLEDGE: A BIOLOGICAL PERSPECTIVE

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Man is a kind of animal, a part of a larger ecological system. It is only recently that the public at large, and scientists in particular, have begun to recognize the far-reaching importance of this simple fact. One of the profound implications of this realization is that man is a product of evolution, an organism that carries with it biases and tendencies that were required for survival millions of years ago. This is far from the blank-slate view of man that has been so influential for so long. One sort of bias one might expect of such a product of evolution is toward various kinds of natural stimuli. Forests, flowers, cliffs, flowing water, animals large and small, all of these may have special significance to an animal whose world and hope for survival was defined in such terms until very recent times.

Another sort of bias one might expect in man concerns not specific stimulus patterns but information in general. The unique aspect of man's evolution is the necessity of living by his wits. As a grounded ape of not particularly formidable proportions, man was forced to survive by anticipating danger well in advance. Admittedly the arboreal environment had led to the development of excellent vision and uniquely flexible response capability through the combination of the upright posture and the grasping hand. But a cleverly crafted plan and a cleverly crafted tool in the hand were necessary to take advantage of these natural assets. Anthropologists now recognize that man began as a ground-dwelling ape with a comparatively small brain. It appears that the planning and anticipating required for survival favored the development of a substantially larger information-handling capacity.

In this perspective it is clear that prediction is one of man's most important talents, interests and concerns. Prediction in turn depends on familiarity with the objects and situations characteristic of his environment. One must know what is happening, where one is in one's environment, before one can ascertain what might happen next. To these two basic skills of recognition and prediction must be added the capacity to evaluate possible outcomes and the capacity to select suitable actions. An additional requisite for all these skills is speed; relatively speaking, a good guess was always better than indecision. In order to carry out all these activities with adequate speed, it is necessary for the organism to store large quantities of information. Further, this storage must allow rapid retrieval despite incomplete information and noisy backgrounds.

An efficient solution to these interlocking problems involves the storage of information about objects and situations into schematic groupings, each representing a class of objects or situations that recurs with reasonable frequency in the environment of the organism. Such representations make possible the rapid recognition of familiar objects and situations. Each representation is associated with other representations; in this way, predictive information is stored. In other words, just as an active representation corresponds to a current environmental situation, the associates of that representation code those situations most likely to happen next. Knowledge of many possible situations and of what leads to what constitutes a cognitive map. Further associations to pleasure and pain units, and to action representations, extend the organism's capability to include evaluation and action.

There are several implications of the proposed approach. First, much of what we know of the way man perceives and knows his environment can be accounted for within a framework based on the adaptive pressures man faced and the biological components available to meet these pressures. Second, since knowledge is essential for survival, its acquisition must be a matter of highest priority. Thus curiosity, exploration, and other expressions of human restlessness when not under pressure play a crucial role in insuring that a wide range of information will be available when needed. Third, man's very survival may depend on these basic information processing mechanisms. Man's capacity to predict and to represent to himself environments not currently present provide a basis for looking ahead, for anticipating the future. A clearer idea of where we are headed, if widely shared, could have an important impact on our adaptive potential.

(Note: The Symposium discussion will be based on a more extensive discussion of these issues, "Cognitive maps in perception and thought," which will appear in R. M. Downs and D. Stea (Eds.), Cognitive mapping: Images of spatial environments. In press.)

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SOME REQUIREMENTS FOR A THEORY OF ENVIRONMENTAL COGNITION: AN INFORMATION PROCESSING VIEW

Preliminary Summary for Comments at the Symposium on Environmental Cognition, Third Environmental Design Research Association Conference

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A theory of environmental cognition will have to encompass so braod an area as to be, in effect, a theory of the mind in interaction with physical-social environment. That theory will have to include an account of mental substructures in interaction with each other and with sense data to codify and to make use of new and past experience.

To bring together the many pieces of relevant knowledge, and to formulate new inquiry that will not merely address a narrow sub-field of investigation, we shall require a conceptual framework capable of unifying study in environmental cognition. It should be capable of including and intertranslating the different languages and schemes now in use to discuss aspects of environmental cognizing acts. It should assist us to bring together for comparison diverse accounts of broad, mid-range, and micro-events occurring in the rich variety of cognizing acts undertaken in different contexts.

Such a conceptual framework is emerging. It is still in rudimentary form. It comes from the information sciences, linguistics, and the branch of psychology currently heavily influenced by artificial intelligence and by Piaget: information processing psychology.

The symposium comments will select a few key issues which must be confronted by theorists of environmental cognition, translate them, at least partially, into information processing terms, and examine their implications in those new terms. The issues to be noted include: Piagetian and Brunerian stages in relation to immediate environmental problem solving, and to the cumulating structures subserving environmental intelligence; requirements for understanding décalages; kinds of description and of data structures, their possible analogues in environmental cognizing structures in man, and their implications for communication among those structures; higher level heuristics and strategies operating on descriptions; major modes of response to environmental stimulation and switches among those modes; flexibility of cognizing in relation to purpose and relative sufficiency of a cognitive structures in relation to opportunities for staging partial hypothesis-making, active exploration, and feedback exercises.

ELEMENTS OF A GENETIC-STRUCTURAL THEORY OF THE DEVELOPMENT OF ENVIRONMENTAL COGNITION

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In the recent interest in environmental cognition (cognitive mapping, urban imagery, and the like), little attention has been given to the study of its development. The issue here is to describe and understand how the human organism comes to form images about the structure, meaning, and function of the environment. To address this problem, we may ask a series of questions:
1. How does the child's conception of space develop? Is knowledge of space innate, a function of maturation, learned as a copy of reality from associations between sensations, or some interaction of these?
2. How does the child come to know spatial concepts? Is there a sequence of stages in understanding?
3. How does the child come to know the spatial entities and relations of large-scale environments like neighborhoods and cities?
4. What is the relationship between this development and that of more basic spatial concepts? For example, does the child's knowledge of large-scale spaces depend on his knowledge of fundamental spatial concepts or does the development of fundamental spatial concepts depend on experience in large-scale environments?
Once we know something about the general course of development, we may ask a series of questions about what variables influence this development, for example, the role of different modes of experience (action, perception, the emotions), the effects of the social reference group to which an individual belongs and of other socio-economic variables, the effect of different styles of representing space, the relation between preferences and attitudes toward environments and the development of knowledge about these environments, and so on.

Having described this development, we may then ask how to explain it, i.e., how can we explain the processes by which the child comes to know about space and about spatial entities like cities?

An assumption underlying this set of questions (and, by implication, the rest of this paper) should be made explicit. In many areas of knowledge, a distinction is made between structure, meaning, function, and development. For example, in the study of environmental imagery, Kevin Lynch has suggested that an image may be analyzed into aspects of the identity of elements and their interrelationships, i.e., structure, and aspects of meaning (1). David Seamon, in another paper in these Proceedings, has extended this framework and found it useful to organize the wide variety of recent studies on environmental imagery (2). In the study of more general psychological phenomena, the distinction is often made between the structure of an intellectual act and its function, and between structures and the processes of their formation (3). Each pair of these concepts is a dialectic between opposites: structure-meaning, structure-function, and structure-development. In the social and behavioral sciences, we see exemplars of relatively pure versions of each extreme, for example, Levi-Strauss, Chomsky, and the Gestalt psychologists as pure structuralists (i.e., ungenerated structures), Skinner, Spence, and other behaviorists as believers in continuous change without structure (structuraless genesis), Malinowski as a functionalist, etc. (4). Nevertheless, there have been strong arguments against dividing the study of behavior in this way, but rather for considering simultaneously the dynamic interaction between structure and development, structure and meaning, structure and function, and so on (5). For analysis, it is often necessary to focus first on one pole, then the other, while keeping in mind the dynamic interactive whole.

Thus, for two reasons, this paper will focus on the development of the child's understanding of the structure of the environment. First, little work has been reported on the development of either the meaning attached to space by children, or on their understanding of the function of different environmental elements and processes (6). Second, it seems the understanding of structure is primary. Not until the child understands something about the elements and relations of the spatial environment can he understand the function of these elements, nor can he invest them with meaning. Thus, function and meaning are overlayed on structure. It is hoped that the theory can be extended to include function and meaning. The focus of discussion, however, does take into account the dialectic between the structures of intelligence and the processes of transformations between structures (i.e., structure and genesis).

In a recent review of the literature, Roger Hart and I (7) found very few people working explicitly on the development of the cognition of large-scale environments (of whom Dave Stea and Jim Blaut, who have done the largest amount of empirical work, are contributing to this Symposium (8).) However, we did find two large bodies of literature which bear implicitly on these issues: one from developmental psychologists interested in basic spatial concepts, the other from a wide range of geographers, urban planners, psychologists, and educators concerned with large-scale environments, both having paid little attention to the work of the other. Attempting to synthesize these findings, our review concentrated mainly on a structural description of the development of environmental cognition.

In the next section, I will discuss four central issues by highlighting some conclusions drawn from these findings, and then in the third section, I will suggest how we might explain this data and begin to build a comprehensive theory.

Structural Description of the Development of Environmental Cognition

1. How does the child's conception of space develop? Is knowledge of space innate, is it learned from sensation, or is it some interaction of the two?

This is a question for which there is no simple empirical answer. It is questionable whether there is any strictly empirical way to answer such a question. A resolution will come not from the findings of a crucial experiment as much as from the interpretation of evidence from a wide range of arguments and experiments.

As with many behavioral questions, there have been two traditional positions taken on this issue. On the one hand are the nativists who stress the importance of heredity and maturation. In this view, knowledge of space is innate, and appears with the maturation of physiological substrate. Other than some early geographers who believed that the sense of direction was vestigial (9), there do not appear to be any strict maturationists in environmental cognition. On the other hand are the empiricists who stress the importance of stimulation from a real environment. In this view, the conception of space is a "copy of reality" learned from the association of sense-experience. Several experimenters have worked within this learning-reinforcement theory, investigating, for example, how a "learned model of a city" is formed by perception "of those elements that have a high probability of occurrence in the immediate environment" (10).

It would be a mistake to think that in all domains the epistemological alternatives reduce to just two. Over and beyond both the nativist-maturational theories and the reinforcement learning theories, there is a third, that of an interactional-constructivism (11). There can be no complete understanding of truth in either pure reason or sensation. Kant argued, instead of naively assuming that knowledge can represent exactly what is "real", we are led to the conclusion that what we take to be real is a product of the act of knowing and thus an interaction between the subject and the object, i.e., a construction of thought (12).

Much research has been aimed at shedding light on this issue. One set of experiments has indicated that the infant has no conception of "space" nor of objects independent from himself. When the experimenter puts a toy out of the sight of the infant, he doesn't search for it, even though he shows obvious displeasure at the loss of the toy. He believes that what he doesn't see ceases to exist ("out of sight, out of mind"). Later (around 16 or 18 months), the child actively searches for the toy until it is found -- he has come to realize that the object still exists in space even if temporarily hidden. Although initially the toy seems to exist only as a direct result of being able to manipulate it, the child finally develops a stable cognitive representation which transcends either tactual or perceptual stimuli. This formation of what is called the "object concept", far from being either innate or given simply through sense-experience, seems to be constructed little by little through a dynamic interaction between the child and the environment (13). Other experiments lend support to the idea that all concepts of the environment develop as a result of an interaction between internal organism factors and external stimulation, that the stimulus is not ready-made but is a function of the active construction of the organism (14).

2. Is there a developmental progression in the child's understanding the environment, and, if so, what stages exist along the way?

It seems quite definite that the child's understanding of space progresses developmentally. Considerable research has also established the existence of stages (15). There are three interlocking domains in which these stages of development occur: fundamental spatial concepts, cognitive schemata of large-scale environments, and levels of spatial organization (see Figure 1). Fundamental spatial concepts include such basics as proximity and separation, paralleleity, perpendicularity, equal intervals, distance, etc. The child's understanding of the spatial relations of large-scale environments has been referred to as "cognitive mapping" (16). Because it begs the question to suggest that the cognition of large-scale environments is limited to cartographic map-like representations (17), it might also be referred to as the development of macro-spatial concepts or as the development of cognitive schemata of large-scale environments. The other domain, levels of spatial organization, concerns general intellectual structures or operations, for example, the difference between intuitive semi-understandings and formal mathematical understandings of space. It has been investigated as part-and-parcel of work on fundamental spatial concepts, although it also cross-cut the macro-spatial work. Because it is the basis for the other domains, let's look first at levels of spatial organization.

Structure: Levels of Spatial Organization. Piaget has found that the development of spatial understanding may be divided into four major periods (18; see Figure 1).

During Stage I, sensorimotor or action space (until about 18 months to 2 years), the infant is limited to a space of action as no internal or cognitive representations are yet possible. By the end, he has extended various actions spaces into a coordinated whole. The child is now able to move freely and confidently through a limited spatial domain, for example, he can take short-cuts not attempted or directly experienced before, return to a point of origin, and detour around an object in order to get to another place (19). The organization of sensorimotor space along with the development of the object concept provides the base for all subsequent developments of spatial knowledge.

With the advent of the symbolic function (around 2), representational or "known" space begins to develop (20). The child reconquers the obstacles overcome in sensorimotor space, but this time on the level of symbolic representation. This internalization occurs in three additional stages, ordered by degree of organization. Stage II (from about 2 to between 5 and 7) is the stage of intuitive or preoperational space. Intuitive space is still subject to the limiting conditions of sensorimotor and perceptual activity: the first images or representations of space merely evoke successive states that have already been carried out on manipulated or perceived objects or environments, and are still tied to the child's own point of view (21).

The child's conception of space gradually develops into the fully flexible and reversible structures of Stage III, concrete operational space (from about 7 to 11 or 12). During early school years, spatial thought is transformed into the beginnings of imageless logical operations, which are, nevertheless, still concrete, that is, still dependent on the presence of real or represented objects (22). However, the spatial structures are for the first time formed through a mental coordination of space as seen from multiple viewpoints (23). Finally, in Stage IV, formal operational space, the spatial thought of the adolescence transcends concrete action, objects, and space -- he can mentally survey the whole universe of spatial possibilities (24).

Content: Specific Spatial Relations to be Constructed. Piaget and his colleagues have also conducted over 30 experiments on the child's construction of various spatial concepts (25). From this research, there appears to be three classes of concepts constructed: topological concepts like proximity and separation, open and closed forms; perspective or projective concepts like the straight line, triangle, or parallel lines; and euclidian or metric concepts like angles, equal intervals, and distances.

Piaget has also found that these three classes of concepts develop sequentially. In one experiment, he had children match two sets of solids and shapes, one which they could only touch and the other only see. Only by transforming both tactile-kinesthetic impressions from one set and perceptual impressions from the other into an internal representation or image can the comparison be made. The experiment was a test of the child's ability to form cognitive representations of various spatial relations. The findings indicated that the child is unable to differentiate toplogical shapes until part way into the preoperational period (about 3 to 5), followed by a steady development of the representation of projective and euclidian concepts until by the final equilibration of concrete operations (around 10 or 11), the child is able to represent and coordinate complex euclidian concepts like the conservation of length and area easily and accurately (26). Thus, by the stage of concrete operations, the preadolescent seems to possess operational knowledge of all the fundamental concepts, properties, and relations of space.

3. How does the child come to know the spatial entities and relations of large-scale environments? Are there developmental steps to the growth of this knowledge? How are large-scale environments represented in thought, and how does this process develop?

Here we address the issue of knowledge of the structure of large-scale environments. Much less work has been done in this domain than in the others, much of it anacdotal and fragmentary. It seems there are two parts to the structure of any image or representation of a large-scale environment: a reference system which spatially orients the individual to the environment and provides a framework for images or representations of specific elements (27).

A number of investigators have posited three types of reference systems (28). The first one was Claparede's 1903 study which suggested three main systems: egocentric (based on the position of the person), realistic (the direction of nearby major features, like streets and rivers), and coordinated (orientation to the cardinal directions). Trowbridge in 1913 and Gregg in 1933 found evidence of a domocentric system (centered on the home). Studies by Lord and Angyal confirmed the egocentric and conventional-abstract

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systems. In total, these findings suggest two definite systems, egocentric and conventional-abstract, and a third intermediate domocentric system.

None of these investigators asked the developmental question as to whether these three systems occur sequentially in the child. Piaget has provided the only comprehensive findings on this question (29). His work supports the tripartite division, and strongly suggests a sequential development. One of his experiments investigated the development of cognitive schemata of changes in positions in the environment. Children were asked to build a sandbox model of their school buildings and environs, to draw the route from school to a well-known landmark, and to make necessary changes after the school building was rotated 180 degrees. Three stages were found. Initially, landmarks were not organized together, routes were thought of only in terms of the child's personal actions, and the plan could not be rotated, characterizing an action-centered egocentric reference system of early preoperational children. The second stage corresponded to the domocentric system, however reference was not only to the home, but to any number of familiar places, routes, and/or landmarks important in the child's experience, which Roger Hart called fixed systems of reference (30). Finally, in the third stage, each part of the schema is in relation to all others in a systematic and coordinated way, thus defining the coordinated system of reference developed fully by the concrete operational stage.

Some recent findings on "cognitive mapping" in adults echo the fixed and coordinated systems of reference, and suggest something about different types of schemata of large-scale environments. Shemyakin distinguished between two systems: route-mapping and survey-mapping, the former constructed "by tracing the route of locomotion through an area", and the latter by representing "the general configuration or schema of the mutual disposition of local objects". Similarily, Donald Appleyard found two systems: sequential and spatial. Finally, George Rand found evidence for both a prior development of route-mapping in children, and a prevalence for route-mapping in adult taxi-drivers in contrast to the "relationship-mapping" of pilots (31). In each case, there is reason to believe that sequential or route-mapping is a developmentally lower form of representation than the spatial relationship, or survey-mapping (32).

4. Is there some relation between the development of spatial schemata of large-scale environments and the

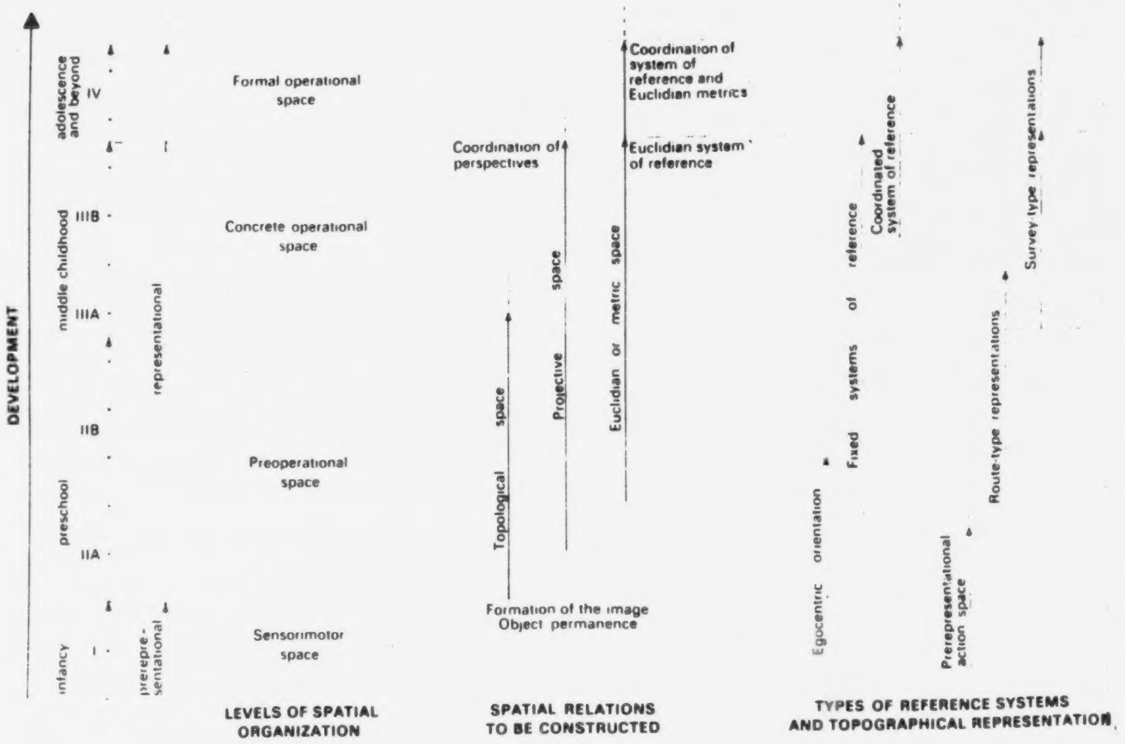
DEVELOPMENT
adolescence and beyond
IV
middle childhood
IIIB
IIIA
IIB
preschool
IIA
infancy
I
representational
prerepre-sentational
Formal operational space
Concrete operational space
Preoperational space
Sensorimotor space
LEVELS OF SPATIAL ORGANIZATION
Coordination of system of reference and Euclidian metrics
Coordination of perspectives
Euclidian system of reference
Topological space
Projective space
Euclidian or metric space
Formation of the image
Object permanence
SPATIAL RELATIONS TO BE CONSTRUCTED
Egocentric orientation
Fixed systems of reference
Coordinated system of reference
Prerepresentational action space
Route-type representations
Survey-type representations
TYPES OF REFERENCE SYSTEMS AND TOPOGRAPHICAL REPRESENTATION

Figure 1. Diagram showing the relations between parallel progressions in the overall development of environmental cognition.

development of fundamental spatial concepts? Are they similar? Do they follow the same developmental laws? Is there a functional relationship between them, for example, does the child's knowledge of large-scale spaces depend on his knowledge of fundamental spatial concepts, or does the development of fundamental spatial concepts depend on experience in large-scale environments, or do these two interact in some way?

Here we come to the crux of the comparison between the development of fundamental spatial concepts and cognitive schemata of large-scale environments. Analysis and comparison of the research findings described above strongly indicates a very close tie between these two developments. Figure 1 illustrates some of the relationships. The left of the diagram illustrates the two main areas in the development of spatial understanding, one prerepresentational or action-centered, and the other representational or knowledge-based. Because the development of both fundamental concepts and more complex cognitive schemata (topographic representations) seem to depend in part on the attainment of different levels of spatial organization, the dotted lines indicating these major developmental periods are carried across the diagram.

Looking across the diagram horizontally, we note that in the prerepresentational sensori-motor period, the infant moves in a space of action, but that near the end of this period, the first images develop. His orientation to the larger environment is egocentric, and includes neither reference systems nor cognitive schemata.

As spatial actions become internalized and images and other intuitive representations of space are constructed, the child enters the preoperational period of spatial organization. During this period most topological concepts are formed and projective and euclidian relations begin to be constructed. With these come the first reference systems and cognitive schemata of large-scale environments. Egocentric orientation gives way to a fixed system of references, centered first on the home (domocentricity) and later on a small number of routes, landmarks, and/or familiar places (more general fixed systems). The child no longer operates solely in a space of action, but begins to represent familiar routes and places (route-type representations), although still in an uncoordinated manner.

With the beginning development of concrete operations, other projective and euclidian relations continue to be constructed. After the child can coordinate perspectives and frames of reference, both of which happen with the equilibration of concrete operations, the representations of discreet parts of the environment (e.g., routes, landmarks, edges, or barriers, buildings, etc.) begin to be coordinated into complex cognitive schemata based on a conventional-abstract system of reference.

Finally, with the onset of formal operations, the adolescent constructs the concepts of area and volume, and is able to consider a theoretical space totally abstracted from any concrete particulars.

One additional trend in these findings should be noted from the diagram. The two sets of parallel developments on the right (reference systems and types of representations) seem to develop slightly later than the two sets on the left (levels of spatial organization and fundamental spatial relations). For example, fixed systems of reference don't seem to develop until some topological, projective, and euclidian relations are already formed, and coordinated systems of reference for large-scale environments seem to develop later than euclidian systems for more immediate spatial concepts and depend on the prior attainment of a concrete operational level of spatial organization (33). We shall have more to say about this in the next section as we try to see what sort of explanatory model fits this data.

A Tentative Genetic-Structural Explanation

Now that we have summarized the major findings, how can we explain and render intelligible this development? A distinction is often made between particular data (facts), uniform empirical regularities (laws), and principles to account for the laws and facts (explanations). As Hempel says, "Empirical laws are explained by means of theoretical principles that refer to structures and processes underlying the uniformities in question". A uniform law accounts for specific data by including it as a logical-deductive part of a larger system, while a system of explanatory principles ultimately accounts for data and laws by relating them to underlying testable theoretical principles (34).

Two main developmental theorists have made significant contributions to the explanation of the development of spatial cognition -- Heinz Werner and Jean Piaget. It is our assertion that their explanatory models also snuggly fit the data on the development of cognitive schemata of large-scale environments.

One of the principles of development described by Werner is the orthogenetic principle which states that there is a progression from a state of relative globality and lack of differentiation to states of increasing differentiation, articulation, and hierarchic integration. The principle defines development in terms of the degree of organization of a system and, thus, may also be used for both change over time and the conceptual ordering of contemporaneous systems.

Following from this principle are three general laws of development and five polarities of development (37). The law of progressive self-object differentiation states that initially, the organism cannot differentiate self from environment, but later is able to differentiate self from object, and subsequently among various objects. The law of progressive constructivism states that as development proceeds, the organism becomes increasingly capable of initiating and determining its own actions and perceptions and begins construction of its own universe. Finally, the law of progressive perspectivism states that although the view of the young child is egocentrically tied to his own actions, the child becomes increasingly able to differentiate its viewpoint from that of others and to adopt and coordinate the perspectives of others.

The five polarities are context-free and time-free principles which characterize levels of development. With regard to the function of behavioral, ends or goals develop from being interfused to be subordinated one to another, that is, from a lack of differentiation between ends to their differentiation and hierarchization, and, similarily, the means develop from being relatively fused or syncretic to becoming discrete one from another. With regard to structure, behavior develops from being diffuse to articulate, that is, from global to clearly segmented movements related to the whole of the act. Finally, with regard to the dynamics of the organism, development is a dual movement from rigidity to flexibility and from lability to stability, or, in other words, with development the organism is more capable of genuine modification in response to changes in the organism-environment system, yet it regains integrity in the face of rapid fluctuations.

At least seven of these eight laws fit the data reported earlier on the development of environmental cognition. The space of the child initially is undifferentiated from his own body, but as self-object differentiation progresses, the near-space of the child's immediate reach is differentiated from proprioceptive body-space, and later, a further differentiation leads to the far-space of perception. The child's interaction with the environment progresses from the passivity of the prenatal child to the pre-adolescent's active construction of "spheres of reality" through contemplation, a shift from passive acceptance to active construction. The progression from egocentrism to perspectivism is indicated by the shift from a space-of-action of the child's body, to a coordinated abstract sys tem. Finally, the child's space-of-action is characterized by its diffuse and undifferentiated structure (the child does not develop a space of interrelated parts), by a syncresis and irreversibility of means of operating on it (the young child cannot reverse his route, he gets lost if he has to start from a new point on a route), and by a rigidity and instability of dynamics (the child's notion of space is rigidly tied to particular objects and relationships). The only dimension which does not seem to apply is that of the interfusion to subordination of ends; this concerns the function rather than the structure of knowledge (38).

In the second section of this paper, several general uniformities found by Piaget were discussed, in particular the four levels of spatial organization and the three types of spatial concepts. Underlying these uniformities and beginning to give them explanatory support, is another more general set, namely Piaget's system of stages in overall development. There are four principle stages, corresponding to the four stages of spatial organization: sensorimotor, preoperational, concrete operational, and formal operational. These stages cross-cut all development -- cognitive-intellectual, perceptual, social, and moral (39).

But invoking Werner's eight laws and Piaget's four stages as underpinnings still leaves us on the borderline between description and explanation. How are we to explain the levels of spatial organization, the sequence of construction of spatial concepts, the sequence of egocentric, fixed, and coordinated systems of reference, and finally, the development of fundamental spatial concepts before the corresponding schemata for large-scale environments?

To do this, we must look at the basis of development. The motivation for all development is adaptation, which, more than mere survival, includes development from lower to higher orders of functioning. Intelligence is one form of adaptation. Although adaptation is intrinsic to all living species, intelligence is not inherited in any strict sense, but rather is formed through a constructive interaction between the organism and its environment.

We do inherit, however, a mode of intellectual functioning comprised of two functional invariants: assimilation (the incorporation of different modes of experience of the environment into internal structures, or schemas), and accommodation (the readjustment of the structures to take in more of the external world). Neither assimilation nor accommodation can ever work to the exclusion of its complement: by incorporating new elements of the world into earlier schema, intelligence constantly modifies the schema in order to adjust them to new elements. Adaptation is the progressive equilibration of assimilation and accommodation. This ever-active functioning assures the construction of knowledge about the environment and the transitions between stages. Each stage is a reflective abstraction on the preceeding one: environmental experience is internalized into a structure once removed; with subsequent development, higher orders of abstraction and equilibration are achieved (40). But the question now arises: How do we apply this general explanation of development to environmental cognition?

By invoking Piaget's functional invariants and operational levels and Werner's developmental progressions, it is possible to understand the sequence of levels of organization of the known environment. Through the dual processes of assimilation and accommodation, the infant builds patterns of sensorimotor schemas, for example, grasping an object in his crib and pulling it toward him. Simultaneously, the infant develops his first perceptual schemas, which soon become coordinated with the motoric schemas (reciprocal assimilation). These rudimentary perceptual-motor schemas seem to have an ubiquitous tendency toward repitition (functional assimilation), and are forever incorporating more elements of the environment (generalizing assimilation), while being altered as they accommodate to newly assimilated experiences. Concurrently, each schema undergoes internal differentiation such that the infant articulates structures formerly fused together. Thus, the processes of assimilation and accommodation lead to progressive self-object differentiation and to the differentiation, coordination, and hierarchic integration of schemas.

This development is, nevertheless, still at the level of action: no images or internal representations are yet present. Piaget's research has shown that these patterns become internalized sufficiently to give rise to something like an image. The genesis of the image emanates from the internalization of deferred imitations. Initially, the sensorimotor child imitates other people's actions, but as this imitation schema is internalized and deferred, the response becomes symbolic (41). Once the child has the ability to form images in one domain, this is quickly generalized to other domains, like space. This important development leads to the beginning of the cognitive representation of environmental space.

The organization of representational space occurs at three levels: intuitive partial operations, reversible concrete operations, and abstract formal operations. As we have seen, preoperational representations or schemas are still subject to the limiting conditions of sensorimotor and perceptual activity. Although certain rudimentary and isolated cognitive transformations can be performed, the representation of space is essentially static. Preoperational representations are also egocentric. However, during the early school years, due to the accommodation of general structures to the assimilation of experiences in the social as well as intellectual realms, spatial thought becomes decentered from single points of view, and different points of view become differentiated, transformed, and coordinated into logical operations (42). Concrete operational structures are formed through the coordination of perspectives from multiple viewpoints (43). The child has moved from an intuitive understanding and partial organization of space to a fully operational and logical organization of space in which elements and relations are able to be combined, associated in different sequences, and logically reversed in thought. Thus, we see the dynamic interaction between progressive perspectivism and the development of concrete operational space: both develop as a function of the other and reach a common equilibrium. The equilibrium of formal operational space is due to a further reflective abstraction.

The next regularity to account for is the three stage progression of the child's knowledge of specific spatial relations, i.e., why it is the child comes to know topological concepts before projective and euclidian, and why projective and euclidian develop in parallel, reaching an equilibrium with the stability of concrete operations.

As we have seen, the first topological concepts (like open and closed space) begin to be formed with preoperational intelligence and are equilibrated by the middle of this period. The acquisition of these concepts depends primarily on rudimentary differentiations, for example, between in and out, and does not require more advanced differentiations. Other topological concepts, such as separation and spatial order, depend on the initial development of the reversible structures of concrete operations, as they depend on the ability to handle logical intellectual operations like transitivity (A next to B, B next to C, implies A not next to C, i.e., separation; and A left of B, B left of C, implies A left of C, i.e., spatial order).

That projective and euclidian concepts lag behind topological concepts in their development is easily understood as they each depend on topological constructions, i.e., the child can't develop the notion of equal intervals (a euclidian concept) until he understands the notion of parallel lines (a projective concept), which in turn he can't grasp until he understands the more basic concept of a straight line (an early projective concept) and ultimately the difference between open and closed forms (a topological concept).

But let us look also at the other end of development, namely why it is that the final equilibrium of projective space is reach by the stage of concrete operations, while only a temporary equilibrium of euclidian space is reached by this time, the final equilibrium waiting until formal operations (see Figure 1 again). Empirically, the last step in the development of projective space is the coordination of perspectives, which occurs concurrently with the equilibration of concrete operations. With the earlier development of the conception of the straight line, the child has, as Piaget says, "grasped the essence of the projective concept: the line is still a topological line, but the child has grasped that the projective relationship depends on the angle of vision or point of view" (44). Here we have one of the three explanatory principles underlying the development of projective space: progressive perspectivism -- the child begins to decenter from his egocentric point of view and to assimilate new information, all the while accommodating his formerly egocentric schemas in such a way that he begins to realize that certain spatial concepts depend on one's point of view. The final equilibrium of the coordination of perspectives also depends on two other explanatory principles: reciprocal assimilation and the reversible structures of concrete operations (the latter in turn depending on the coordination of perspectives). Egocentrism continues to give way to perspectivism, and as a consequence, two differentiated schemas begin to be developed: before **versus** behind, and left versus right. The child is able to decenter from one point of view and to center on another. As these decentrations and recentrations are accomplished more rapidly, the two schemas reciprocally assimilate each other and become intercoordinated into a reversible equilibration -- the coordination of perspectives.

Similarily, a partial equilibration is reached as the concrete operational stage wherein approximate distances and equal intervals can be grasped, as well as differences between acute, right, and obtuse angles, resulting in a coordinated system of reference. This development is also due to the progression from egocentrism to relation coordination and the equilibration of concrete operations. For example, the concept of the conservation of length and surface depends on the child's discovering through logical reversibility that a quantity has remained the same even though a transformation has occurred.

The final equilibrium of metric space involves the coordination of the concepts of exact length and surface with the new concept of three-dimensional volume. This coordination isn't achieved until the stage of formal operations, as the concept of volume depends on the formal abstraction of infinity (45).

We come now to the second to the last set of data to be explained. Considerable evidence has been reported above that in developing cognitive schemata of large-scale environments, the individual utilizes a framework or system of reference for orientation and for interrelating different elements and himself. The notion was advanced that this system of reference is the most important component in cognitive schemata. We have also seen evidence that the development of this framework proceeds through three periods: from egocentric orientation, through various fixed systems of reference, to an abstract coordinated system of reference. The overall organization ofthe cognitive schemata proceeds from route-type to survey-type representations. Furthermore, coordinated reference systems and survey-type representations reach stability cotemporally with the equilibration of concrete operations. The present question, therefore, is to explain the particular sequence of these various stages (structure), while accounting for the transitions between stages (genesis).

We have seen in the period of egocentric orientation that landmarks are uncoordinated and changes of position cannot be described. Children at this stage can arrange in thought two objects in isolation, but cannot synthesize the links between pairs (46). Initially, the child's movements are organized as a system of sensorimotor connections between routes and places (47). Subsequently, construction is intuitive but does not permit inversion, for example routes are unidirectional and cannot be reversed in thought. Construction of representations is also egocentric, for example, "distance between places is proportional to subjective interest. Thus, the latter part of this period of egocentric orientation is clearly a function of the child's first uncoordinated preoperational spatial structure.

Likewise, the second stage of fixed partially coordinated systems of reference is a product of the later preoperational structures, and develop with the coordination of concrete operations. As Piaget says, "The elaboration of a coordinate system and grouped representations of movement are interdependent" (48). Although the child at this general intellectual level can coordinate two dimensions, and is beginning to show a coordination of perspectives in the presence of a model, his representations of large-scale spaces are still unrelated and partial because each is from a particular vantage point, and each is fixed in a subgroup of intellectual operations centered on a subjectively important landmark or place. A classic example comes from on of Piaget's subjects who conceptually cut a straight route in half and made one part perpendicular to the other, giving two sub-groups of features corresponding to two quite different walks (49).

Finally, the child constructs a coordinated abstract system of reference which permits coordinated survey-type representations. Even when he deals with two sub-representations or adds a section to a drawing, the child wastes no time in making the different parts agree with each other. From observational data, Piaget has suggested two ways in which this grouping may occur: in some cases relations are constructed between different sites, and in others starting points are established and then routes are constructed from them, similar to Lee's suggestion of a polar coordinate system of reference (50). Lynch has suggested five ways images may be organized, the above two plus: outward from familiar lines of movement, inward from the construction of an enclosing boundary, and by repeating a gridiron pattern and then adding detail (51). Whatever the particular way of organizing the representations, this ability to construct a somewhat abstracted cognitive framework seems to depend on the attainment and equilibration of concrete intellectual operations. These operations take the form of a single comprehensive group comprised (as in the abstract algebra of groups) of four laws: composition (loosely speaking, all parts are parts of the whole), identity (elements retain their identity despite transformations), reversibility (imagining a route in the reverse direction), and associativity (reaching in thought any part by a variety of routes).

In the dynamics of transitions between these stages, the essential point seems to be that the child moves from an egocentric attitude to a coordinate reference system by grouping the elements of experience. Piaget has argued that "operational groupings" are at the root of both a coordinate reference system and topographical representations (52).

As with the other developments we have surveyed, the development of cognitive schemata of large-scale environments is neither a matter of the maturation of innate structures or of the accumulated learning of associations between elements. It is becoming harder to even apply a strict maturational hypothesis to the growth of those phenomena which have traditionally been thougt to have "matured" -- even the growth of body parts is a function of the interaction between organism and environment. With regard to the learning hypothesis, Piaget has noted that if the development of reference systems was merely a matter of accumulation, one might try to explain this development in the following manner: At four years of age, a child is brought to school, and is therefore aware only of the school, his home, and the local candy store; at seven, due to wider geographical experience, he knows a few roads, and can describe fragmentary routes; and at nine or ten, he is allowed to roam freely and consequently knows the layout of his environment intimately. However tempting this hypothesis might appear, it leaves a number of questions unanswered and a number of facts unaccounted for. For example, with regard to the reconstruction of the sandbox model, why is it children cannot rotate the plan through 180° and make the necessary changes to their representation, even though they know their school environs as well from one side (say the street) as they do from the other (say the playground)? Or why, at the age of nine does one of Piaget's subjects talk about two "rues de Carouge", simply because he lives halfway along the route? The conclusion is that the growth of knowledge about the environment is a coordination or integration of representations of the environment -- an infinitely more complex process than the mere accumulation of information.

The factors contributing to the transitions between stages are tied in a vicious circle. In order to represent the environment as a group free from egocentric associations, schemata must comply with an abstract coordinated reference system; but to achieve such a comprehensive system, routes and places must be combined into a coherent group. Again we witness the transition from egocentrism to perspectivism proceeding hand-in-hand with the transition from action to logical thought.

Following from Werner's formulations, this development may be seen as a dual movement from the rigidity of the egocentric and fixed systems of reference to the flexibility of an abstract system, and, similarily, from a syncresis of positions at the egocentric level to the discreetness of locations in an abstract system. This development follow the orthogenetic principle: the changes have proceeded from fusion, egocentrism, and lack of differentiation, through differentiation and articulation of different fixed points of reference, to a heirarchic integration of different sub-groups of the environment.

As a result of adaptation and the interaction of the child and his environment, the child assimilates new elements of the environment and decenters from one point of view. The decentering may take one of several particular forms, for example first breaking up the sensorimotor experienced route into two end points, one where the child currently is, and the other where he was when at the other end. This paves the way for reconsideration (on the level of intuitive thought) of the journey itself. As the earlier and subsequent sensorimotor experiences are internalized into primitive images, short links of the route may take on a character of their own. As new experiences are assimilated, as representations accommodate to these assimilations, and as further decentrations continue, the process leads to the first partial groupings of space, i.e., the beginnings of the transitional fixed system of reference. Journies themselves may be represented as symmetrical intervals between termini. Thus, egocentric relations have given way to relations between objects, and the child sees himself as one object among many in a framework of fixed references. Each sub-grouping of elements and relationships expands as a dual function of new assimilation-accommodation interactions and of internal reflections on earlier schemas. Generalizing assimilation assures that the subgroups will begin to overlap, contradict each other, and include each other. This gives rise to more "aliment" for the structures to incorporate and to accommodate to, which leads in turn to a continuing differentiation of the partial representations. As the overlap and interfusion becomes pervasive enough the structures begin to include each other through reciprocal assimilation, and finally become fully intercoordinated or equilibrated into the structure of the mathematical group, the structure which underlies and accounts in part for the development of environmental cognition.

One issue remains to be addressed briefly: why it is that the development of reference systems and cognitive schemata in large-scale environments occurs later than the equivalent development in more proximal environments. It might be suggested that there are inherently different processes involved in the two situations. Although this possibility cannot be completely ruled out, the weight of evidence suggests clearly that there is great similarity in these developments, and in fact, that both rest on some of the same intellectual developments, namely the orthogenetic principle, progressive constructivism and progressive perspectivism, and the equilibration of the group of concrete operations. The time delay takes on the flavor of what Piaget has called a "horizontal décalage", a temporal displacement of like patterns of development which repeat themselves in slightly different domains but within the same overall developmental period (53). The whole issue of décalages is one of Piaget's admitted three holes in the genetic-structural theory (54) and is not one we are likely to be able to fill here. However, the temporal delay in environmental cognition may be a result of some combination of at least six factors: First, the child's understanding of large-scale environments depends on his understanding of the equivalent basic spatial relations: therefore, fundamental spatial concepts may have to be differentiated and elaborated into large-scale situations, all of which takes time. Second, Piaget has suggested that as the experiments used to assess fundamental spatial concepts are most often done in the presence of the objects or model to be represented, whereas with considerations of cognitive schemata or large-scale environments this cannot be done, memory becomes a factor in the latter case. This is similar to a suggestion, third, which arises from Stea's definition of the large-scale environment as being to large to be perceived at one time or from one position (55), thus a complex interaction may be necessary between perception and cognition in order to understand the structure of large-scale environments. Fourth is the possibility that a slightly more complete equilibration of concrete operations is necessary for the complex juggling of stored images of parts of the environment together with assimilations of newly experienced elements. Fifth is a distractability hypothesis regarding the complexity and confusion of large-scale environments versus the relative simplicity of models. Finally, sixth, is a motivation hypothesis involving the difference between the situation where the child is given a task and encouraged to act on it, and that where some people just don't care how the environment is structured and hense don't put any effort into comprehending it. This hypothesis touches based with a theme which has run thoughout this paper -- the active-passive dimension and its effects in the development of knowledge.

Summary

In this paper, I have tried to trace some of the most important stages in the development of the child's understanding of the structure of the environment and have endeavored to provide a beginning explanation for this development which both accounts for the specific data and conforms with major theories of general cognitive development. With regard to the epistemological question of the subject-object relation, an interactional-constructivist position is taken. From this vantage point, specific data, generalized findings, broad developmental laws, and explanatory models for the development of environmental cognition have been discussed.

Notes

1. K. Lynch, The Image of the City, Cambridge: M.I.T. Press, 1960.

2. D. Seamon, "Environmental Imagery: an overview and tentative ordering", in this volume pp. 7-1-1 to 7-1-7.

3. For the structure-function distinction, see especially H. Werner, Comparative Psychology of Mental Development, New York: International Universities Press, 1948, pp. 53-56d. For structure-genesis, see J. Piaget, Structuralism, New York: Basic Boosk, 1970, pp. 9 - 13 and 60 - 68.

4. See C. Lévi-Strauss, Structural Anthropology, Garden City, N.Y.: Doubleday, 1967; N. Chomsky, Aspects of a Theory of Syntax, Cambridge: M.I.T. Press, 1965; W. Köhler, Gestalt Psychology, New York: Appleton-Century-Crofts, 1938; K. W. Spence, Behavior Theory and Learning, Englewood Cliffs, N.J.: Prentice-Hall, 1960; and B. Malinowski, A Scientific Theory of Culture, New York: Oxford Univeristy Press, 1960. For a general discussion of these positions, see Piaget, Structuralism (see note 3). I am indebted to Jacques Vonèche for pointing out these dialectics and their possible resolutions.

5. For arguments (and suggested methodologies) for analyzing both sides of dialectics, see Werner's discussion of structural and physiognomic properties of objects in Comparative Psychology of Mental Development (see note 3), especially pp. 67 - 82 ff; K. Goldstein's discussion of the part-whole relationship in Human Nature in the Light of Psychopathology, New York: Schocken, 1963, pp. 1 - 10; H. Bergson on the static structure-continuous process dialectic in Time and Free Will, New York: Harper Torchbooks,

1960; and Piaget, Structuralism (see note 3).

6. Two exceptions to this are Werner in Comparative Psychology (see note 3), and Piaget in The Child's Conception of the World, Totawa, N.J.: Littlefield Adams, 1967.

7. R. A. Hart and G. T. Moore, "The development of spatial cognition: A review", in R. M. Downs and D. Stea (eds.) Cognitive Mapping: Images of Spatial Environments, Chicago: Aldine-Atherton, 1972 (in press). A longer version of this review is available from the Environmental Research Group, 529 South Wabash Avenue, Chicago, Illinois 60605.

8. See D. Stea and J. M. Blaut, "From city models to model cities: Theory and research on the growth of environmental cognition", in this volume pp. 30-19-1 ff.

9. See Hart and Moore (see note 7), pp. 51 and 54 in the long version.

10. For examples of this work, see the experiments reported in Part III of Hart and Moore. The work of some of the contributors to this Symposium seems to come from this direction, for example that of R. G. Golledge. The quotations are from R. G. Golledge and G. Zannaras, "The perception of urban structure: An experimental approach", Proceedings, Second Annual Environmental Design Research Association Conference, Pittsburgh: Carnegie-Mellon University, 1971, pp. 112 and 113.

11. In the psychology of cognition, this position is perhaps best represented by Piaget's genetic-structural theory and Werner's organismic-developmental theory. In perception (which is year by year getting harder to distinguish from cognition), the transactional theory of W. Ittleson and H. Cantril and the sensori-tonic/organismic-developmental theory of S. Wapner and H. Werner are perhaps closest to this epistemological position. See J. Piaget, The Psychology of Intelligence, Paterson, N.J.: Littlefield Adams, 1963; Werner, Comparative Psychology, (see note 3); W. H. Ittleson, Visual Space Perception, New York: Springer, 1960; and S. Wapner and H. Werner, Perceptual Development, Worcester, Mass.: Clark University Press, 1957.

12. I. Kant, Critique of Pure Reason, New York: Macmillan, 1902 (originally published in 1787).

13. These experiments are reported in J. Piaget, The Construction of Reality in the Child, New York: Basic Books, 1954, pp. 3 - 96.

14. For the development of understanding of other aspects of the environment, see Piaget, The Construction of Reality, pp. 219 ff; Piaget, Child's Conception of the World (see note 6), and Werner, Comparative Psychology, pp. 382-402.

15. See for example, J. Piaget and B. Inhelder, The Child's Conception of Space, New York: Norton, 1967; J. Piaget, B. Inhelder, and A. Szeminska, The Child's Conception of Geometry, New York: Basic Books, 1960; Werner, Comparative Psychology; and M. Laurendeau and A. Pinard, The Development of the Concept of Space in the Child, New York: International Universities Press, 1971; all of which are summarized in Hart and Moore (see note 7).

16. Downs and Stea, Cognitive Mapping (see note 7).

17. This point is made in D. Stea, "The measurement of mental maps", in K.R. Cox and R.G. Golledge (eds), Behavioral Problems in Geography, Evanston, Ill.: Northwestern University Press, 1969, pp. 228 - 253.

18. J. Piaget and B. Inhelder, The Psychology of the Child, New York: Basic Books, 1969.

19. Piaget, The Construction of Reality (see note 13), pp. 97 - 218.

20. For the formation of symbols, see J. Piaget, Play, Dreams, and Imitation in Childhood (originally La Formation du Symbole), New York: Norton, 1962; and H. Werner and B. Kaplan, Symbol Formation, New York: Wiley, 1963.

21. Laurendeau and Pinard, The Development of the Concept of Space in the Child (see note 15).

22. B. Inhelder, "Operational thought and mental imagery", Monographs of the Society for Research in Child Development, 1965, 30, 4 - 18.

23. Piaget and Inhelder, The Child's Conception of Space (see note 15), pp. 151 -297.

24. Piaget and Inhelder, The Psychology of the Child (see note 18), pp. 130 - 151.

25. These are reported in Piaget and Inhelder, The Child's Conception of Space and in Piaget, Inhelder, and Szeminska, The Child's Conception of Geometry, (see note 15).

26. For the experiment on the formation of images, see Piaget and Inhelder, Child's Conception of Space, pp. 17 - 43, where the distinction is also made between perceptual and representational space. These experiments have been replicated by Inhelder in "Operational thought and mental imagery" (see note 22), and by Laurendeau and Pinard in The Development of the

Concept of Space (see note 15), pp. 28 - 110. The recent findings of Blaut and Stea that first graders can interpret vertical areal photographs, which seems to invoke something akin to the coordination of perspectives, are consistant with this position. See J. M. Blaut, G. F. McCleary, and A. S. Blaut, "Environmental mapping in young children", Environment and Behavior, 1970, 2, 335-349, and J. M. Blaut and D. Stea, "Studies of geographic learning", Annals of the Association of American Geographers, 1971, 61, 387 - 393.

27. For the development of spatial frameworks, see Piaget, Inhelder, and Szeminska, Child's Conception of Geometry. One study on the development of representations of specific elements is D. Appleyard's "Why buildings are known", Environment and Behavior, 1969, 1, 131 - 156.

28. These studies are summarized in I. P. Howard and W. P. Templeton, Human Spatial Orientation, New York: Wiley, 1966, pp. 262 - 263; and in Hart and Moore, pp. 46 - 55.

29. Piaget and Inhelder, Child's Conception of Space, pp. 375 - 446; and Piaget, Inhelder, and Szeminska, Child's Conception of Geometry, pp. 3 - 26.

30. Although it is impossible to divorce my thinking from that of my friend and colleague, Roger Hart, I am particularly indebted to him for organizing the research on reference systems and geographical orientation. See Hart and Moore, pp. 45 - 55.

31. See F. M. Shemyakin, " Orientation in space", in B. G. Anan'yev, et al. (eds.) Psychological Science in the U.S.S.R., Vol. 1, Washington: Office of Technical Services, Report 62-11083, 1962, pp. 86 - 255; D. Appleyard, "Styles and methods of structuring a city", Environment and Behavior, 1970, 2, 100 - 118; and G. Rand, "Some Copernican view of the city", Architectural Forum, 1969, 132(9), 77 - 81.

32. Hart and Moore, pp. 48 and 57 - 58.

33. See Piaget, Inhelder, and Szeminska, Child's Conception of Geometry, especially pp. 3 - 26 and 389 - 406 for experiments and conclusions on this point.

34. C. G. Hempel discusses laws and their role in scientific explanation in Philosophy of Natural Science, Englewood Cliffs, N.J.: Prentice-Hall, 1966, pp. 47 - 85; this quote is from p. 51.

35. See Werner, Comparative Psychology and Werner and Kaplan, Symbol Formation (see note 20).

36. For the general principles, see Piaget, Psychology of Intelligence (see note 11), and for their application to spatial cognition, see Piaget and Inhelder, Child's Conception of Space, and Piaget, Inhelder, and Szeminska, Child's Conception of Geometry.

37. See Werner, Comparative Psychology; Werner and Kaplan, Symbol Formation; and Kaplan, "The study of language in development: The comparative-developmental approach", in S. Arieti (ed.), American Handbook of Psychiatry, Vol. 3., New York: Basic Books, 1966, pp. 659 - 688.

38. These conclusions are derived from findings by Carmichael, Coghill, Stern, and Werner and reported in Werner, Comparative Psychology, pp. 172 - 177.

39. For a general treatment of development, see J. Piaget, Six Psychological Studies, New York: Vintage, 1968, and Piaget and Inhelder, Psychology of the Child, (see note 18).

40. This account is from Piaget, The Origins of Intelligence in Children, New York: Norton, 1963, pp. 6 - 7.

41. Piaget, Play, Dreams and Imitation (see note 20), especially pp. 62 - 88. For their latest research on this issue, see Piaget and Inhelder, Mental Imagery in the Child, New York: Basic Books, 1971.

42. The influence of social factors in decentering and progressive perspectivism is discussed in Piaget, Psychology of Intelligence (see note 11), pp. 156 - 166.

43. Piaget and Inhelder, Child's Conception of Space, pp. 209 - 246.

44. J. Piaget, "How children form mathematical concepts", Scientific American, 1953, 189(5), 74 - 79; quote from p. 75.

45. Piaget, Inhelder, and Szeminska, Child's Conception of Geometry.

46. Ibid., p. 9.

47. Piaget's description of this earliest stage is similar to Hebb's account of learning to navigate a maze (a rat) or a new city (him). His claim is that it is not necessary to have an accurate "picture", only that a "goal-concept" dominate a "phase-sequence" in the physiological structure of the brain, and that each part of the route reliably evoke the next phase-sequence . Hebb's position is not inconsistent with the theory advanced here. He states that on first entering a new area one is likely to have a confused"image of the total

situation". Therefore, Hebb's primitive neurological phase-sequence would seem to be characteristic of the sensori-motor or intuitive period of development (either for the child or for the adult encountering a new situation), when only certin navigations can be performed due to an uncoordinated representation. Something like more complex phase-sequences may underly or be the physiological substrate for higher order cognitive schemata. See D. O. Hebb, *The Organization of Behavior: A Neuropsychological Theory*, New York: Wiley, 1949, especially pp. 134 - 139.

48. Piaget, Inhelder, and Szeminska, *Child's Conception of Geometry*, 1. 15.

49. *Ibid.*, p. 17.

50. T. R. Lee, "Psychology and living space", *Transactions of the Bartlett Society* (London), 1964, 2, 9 - 36; reprinted in Downs and Stea, *Cognitive Mapping* (see note 7).

51. Lynch, *Image of the City* (see note 1), p. 86.

52. Piaget, Inhelder, and Szeminska, *Child's Conception of Geometry*, p. 23.

53. My thanks to Dick Melito who first suggested this possibility.

54. Personal communication from Mlle Denise Piché, from a research workshop involving Piaget at the University of Montreal, October 1972. cf. Piaget's brief discussion of this problem in his introduction to Laurendeau and Pinard, *The Development of the Concept of Space* (note 15).

55. See Stea, "The measurement of mental maps" (see note 17).

31: METHODOLOGICAL PROBLEMS IN ENVIRONMENTAL PERCEPTION AND BEHAVIOR RESEARCH

METHODOLOGICAL PROBLEMS IN ENVIRONMENTAL PERCEPTION AND BEHAVIOR RESEARCH

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Contributions from all the social sciences and design professions to the understanding of environmental perception and behavior have increased rapidly in recent years. Within the discipline of geography, for example, the actual and potential importance of this research is evident in such realms as environmental quality, recreation, natural hazards, and amenity choices. Nevertheless, as a number of recent overviews indicate, the study of environmental perception and behavior as a whole remains essentially unorganized and disjointed. Research in each discipline falls short of realizing its full potential because practitioners lack commonly agreed definitions, objectives, and mechanisms for applying research results to the needs of planning and decision-making bodies. Above all, they require a more systematically organized theoretical base.

This realm of knowledge, crucial for an understanding of the interaction between man and environment, is now at the threshhold of significant generalization. But many fundamental issues require systematic analysis if differences in disciplinary philosophies, vocabularies, and research expectations are to be bridged. The present overview is intended to set the stage for discussions among EDRA conference participants concerned with these issues.

An outline of problems in this field, which may serve to organize these discussions, is as follows:

I. Problems of Definition and Scope

Perception and behavior research as now carried on frequently concentrates on some one parameter of human response - environmental preference, environmental judgment, environmental disposition, environmental behavior in only one of many existing or potential modes. There is little overlap among such studies, and there has been little effort to explore the connections, strengths, and weaknesses of each of these components of what is in reality a general system. Moreover, environments, modes of apprehension, and individual and group dispositions vary widely in ways that may be generally well understood, but have never been codified. An agreed method for the classification of each of these groups of variables is required if we are to utilize the enormous body of research material already generated, let alone what is likely to be developed in the future. A data bank and system of information retrieval are essential adjuncts. Finally, the routes by which environmental perception, intention, and expectation are transformed into environmental behavior need to be traced and mapped. And behavioral alterations of perception involve a system of feedback that also needs analysis.

II. Problems of Content and Context

One of the most fundamental problems to be resolved in studies of perception and behavior is how best to differentiate its extremely diverse subject matter. Distinctions and analogies between physical and social environments may be taken here as exemplifications of a broad range of problems. Most disciplines concerned with perception and behavior research sharply distinguish social from physical environments. Terminology, theory, and practice all separate studies of interactions among people from studies of interactions between people and things. Yet it is clear that the environment as a whole includes social and physical considerations, that the two form an interacting system, and that expectations and behavior relate to social and physical environments in combination rather than in isolation. Indeed, systems of classification used in all cultures interlink the perceived structures of natural and social worlds. We need fuller and more specific delineations of these linkages, in order intelligently to assess environmental dispositions, beliefs, and actions prevalent among different national, cultural, and local communities.

Studies of natural and human hazards provide an illustration of the significance of such an understanding. A substantial body of work has accumulated on responses to natural habitats, and much is known about how humans in various cultural and environmental situations are likely to behave in response to different types of natural hazard. Responses to human hazards, however, are much less well understood; indeed, we can barely surmise the extent to which people of differing cultural and social backgrounds regard various types of hazard as "natural" or "human". A comprehensive effort should be made to link up natural hazard work with disaster and related research, in order to develop a framework within which all hazard responses can be more systematically analyzed.

III. Problems of Technique and Method

A. The Nature of Evidence.

There is little mutual understanding among scholars in different disciplines about the nature of evidence each discipline uses to identify environmental attitudes. The survey questionnaire techniques of the sociologist, the laboratory studies of the psychologist, the participant observations of the anthropologist, and the media sources of the historian, for example, all employ or imply profoundly differing assumptions about what constitutes evidence and proof of environmental views and of the contexts in which they are held. Greater mutual familiarity with the techniques and expectations of all disciplines concerned with environmental perception and behavior is a major desideratum.

B. Environmental Simulation and Environmental Surrogates

Most studies of environmental perception and behavior rely heavily on simulated environments or environmental surrogates, notably in the form of photographs and models. Such surrogates commend themselves to researchers because they can be used with greater economy, speed, and control than can real world situations, and also lend themselves better to measures of reliability. Ultimately, however, the study results are significant only insofar as they may apply to reality. Little systematic effort has been made to ascertain how responses to simulated environments differ from responses to, or behavior in, real environments. The disjunctions moreover differ in form and consequence, depending on the particular mode of environmental observation employed.

C. Semantic Analysis

Most studies of perception and behavior rely heavily on language, usually in the form of questionnaires or interviews. Yet semantic responses explicate only a fraction of all that individuals perceive and do in the environment. Moreover, since languages differ in structure and vocabulary, semantic associations tend to bias responses in ways that differ from culture to culture and, indeed, from class to class and person to person. Yet no systematic statement of these difficulties exists, much less of how to overcome them. The deficiencies of research relying wholly on language and the potential benefits of non-linguistic responses and behavior both require systematic elaboration.

D. Congruence of Environmental Descriptors

Virtually every investigator of environmental reactions, judgments, and preferences has heretofore con-

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structed his own lexicon of descriptors, derived either from terminology utilized by environmental management professions or by reduction from vocabularies selected by test observers. These descriptor lists exhibit a considerable degree of overlap, but they vary with their mode of construction, their length, the type of milieu to which they are applied (outdoor, indoor, urban, rural), observer background, intended mode of environmental experience (standing, walking, driving; real world or surrogate), and the requirements of statistical analysis. Great time and effort is expended in constructing such lexicons, and the differences among them invalidate firm comparisons of research results. To avoid duplication of effort and to achieve comparability of results, a concerted attempt is needed to determine the practicability of standardizing environmental descriptors and to establish guide lines for consensual semantic analysis.

E. Statistical Methodology

Many inquiries into environmental responses, judgments, and preferences seek to develop meaningful clusters of environmental and observer variables through measures of correlation and factor analysis. Owing to their widely differing premises and experimental circumstances, however, most such research programs have tended to operate from different statistical points of departure and to ignore techniques developed in other research. As with environmental descriptors, this involves much duplication of effort, compounded here by the costs of computer programming and operation. Elucidation and comparison of appropriate statistical techniques, both parametric and non-parametric, is urgently required both to save time and effort and to achieve more sophisticated, duplicable results.

IV. Problems of "Relevance"

A. Operationalizing Research

Much research in environmental perception is undertaken in response to specific requests for information on the part of environmental managers and designers - engineers, architects, planners, etc. Yet there is little agreement about which kinds of information perception and behavior research generates are of greatest use to environmental managers, or at what stages in the development of research such information can most effectively be made available. A general statement about the utilization of research in the field might well include caveats on the reliability of data and the extent to which it ought to be generalized or applied in different circumstances.

B. Communication

The presentation of research results has been a major stumbling block in effectiveness. This stems partly from the amorphous nature of the field itself, but is a consequence also of the disparity between the language of research and the language of everyday life. The mathematization of understanding is no doubt essential; no less essential is the need to couch results that can be understood in real world situations. The construction of predictive models is an adjunct to, not an adequate substitute for, empirical understanding.

C. Recruitment and Education

Environmental perception and behavior studies have been carried on by scholars in a wide range of social science and other disciplines. As public demands for environmental control and quality become more manifest, the demand for such research and understanding will also increase. Education in this field has heretofore been on an ad hoc basis, with recruitment operating through a particular discipline in the first instance and students subsequently finding their own ways into cognate fields. To cope with the wide range of expertise required, a more systematic program of environmental perception and behavior studies needs to be worked out in conjunction with the recruitment and training programs of each of the relevant disciplines.

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